POWER

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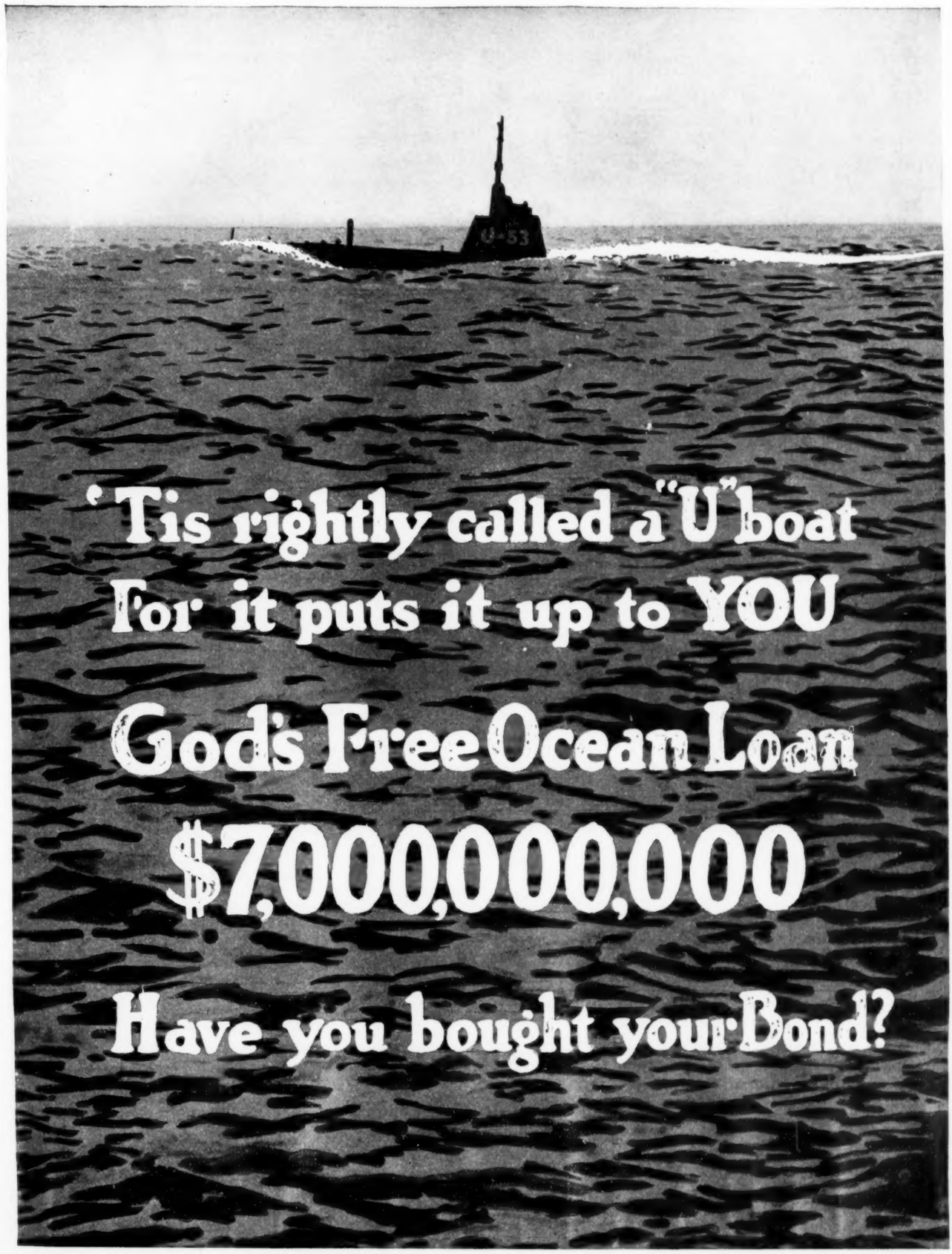


Telephone and Telegraph Building Steam-Power Plant

By Warren O. Rogers

SYNOPSIS—An office-building power plant having several features out of the ordinary. The boiler-feed pumps are protected from dirt and dust by a glass partition. The makeup feed water is run through coils in the blowdown tank, dirty-drip tank and an auxiliary heater before going to the main heater, thereby extracting heat that would otherwise be wasted. Artificial ventilation is provided for the basements and for the twenty-sixth floor by means of motor-driven supply and exhaust fans. All important units and auxiliaries are in duplicate.

Situated at Broadway and Fulton, Dey and Church Sts., New York, is the newly constructed office building of the American Telephone and Telegraph Co. The main portion of the building is 75 x 275 ft. and the Fulton St. wing is 33 x 77 ft. The general height to the parapet is 363 ft. and a tower on the Fulton St. wing adds 60 ft. more in height for that section. The main building has 26 stories above the street level, and there are three more in the tower. Below the street levels there are five basement levels, the lowest one being 76 ft. below the main floor on the street level.

Basement *A* connects with the Broadway subway, and it is here that the bottom landing of sixteen of the passenger elevators is found. From this sub-basement four fireproof stairways lead to the basements.

The building contains an up-to-date steam plant for generating electrical energy for general use through the building. The boiler room, sub-basement *D*, contains five B. & W. boilers, Fig. 1, two of 350-hp. and the others of 400-hp. The furnaces are equipped with Roney stokers and a steam pressure of 150 pounds is carried.

Coal Supply

Coal is delivered through the sidewalk to a coal bunker that extends the length of the boiler room. From the bunker the coal passes to Richardson weighing scales, one for each boiler, each discharging the coal after weighing to the chute feeding to the stoker hopper. Ashes are loaded from the ashpits into a car and are elevated in ash cans to the street level for final disposal.

A feature worthy of notice is the arrangement of the boiler-feed pumps, which are placed about central and at one side of the firing aisle. One is a 3-in. turbine unit, driven by a 15-hp. direct-current motor. The other is a 16 and 9 x 18-in. pot-valve simplex pump. These, together with the 5-in. venturi meter, are protected from the dust of the boiler room by a glass partition, but they are in full view of the firemen.

Handling the feed water to the boilers is also of interest. All return water from the Webster vacuum heating system is pumped to a receiving tank at one end of the boiler room, from which the feed pumps take water, forcing it through the feed-water heater and either of two Beggs filters on its way to the boiler. City makeup water is controlled by a float in the receiving tank, but such water first takes a course through coils in the blowdown tank, where the heat from the boiler blowoff is abstracted. It next goes through coils in the dirty-water drip tank, where the drip from the engine low-pressure exhaust pipes is accumulated, and it then passes through a primary heater whence it goes to the receiving tank to be taken by the feed pumps and sent to the boilers. Heat for the primary heater is supplied in the form of vapor from the blowoff tank, from the dirty-drip heater and also from the main supply tank. By this arrangement practically all of the heat in the drips and waste water is recovered and returned to the boilers.

Engine-Room Equipment

Basement *C* is devoted to the engine room, Fig. 2, where five Rice & Sargent engines, directly connected to G. E. 250-volt 200- and 300-kw. direct-current generators are installed. There are three 22 x 42-in. 450-hp. engines running at 100 r.p.m. and two 20 x 30-in. 300-hp. units at 120 r.p.m. This selection of engine sizes provides for the economical handling of any load that may occur. The absence of all piping in the engine room is notable, both the high pressure and exhaust lines being in a sub-basement. The boilers are piped to a 12-in. main steam header, above and at the back of the boiler settings and extending to the pipe basement below the engine room. An 8-in. auxiliary high-pressure steam line is also provided, with branch lines to the five engines. This arrangement provides against a total shutdown of the plant in case of accident to the main steam-line supply. Throughout, the plant is in duplicate where necessary. This not only includes the boilers and engines, but also the various pumps used in connection with the operation of the power plant.

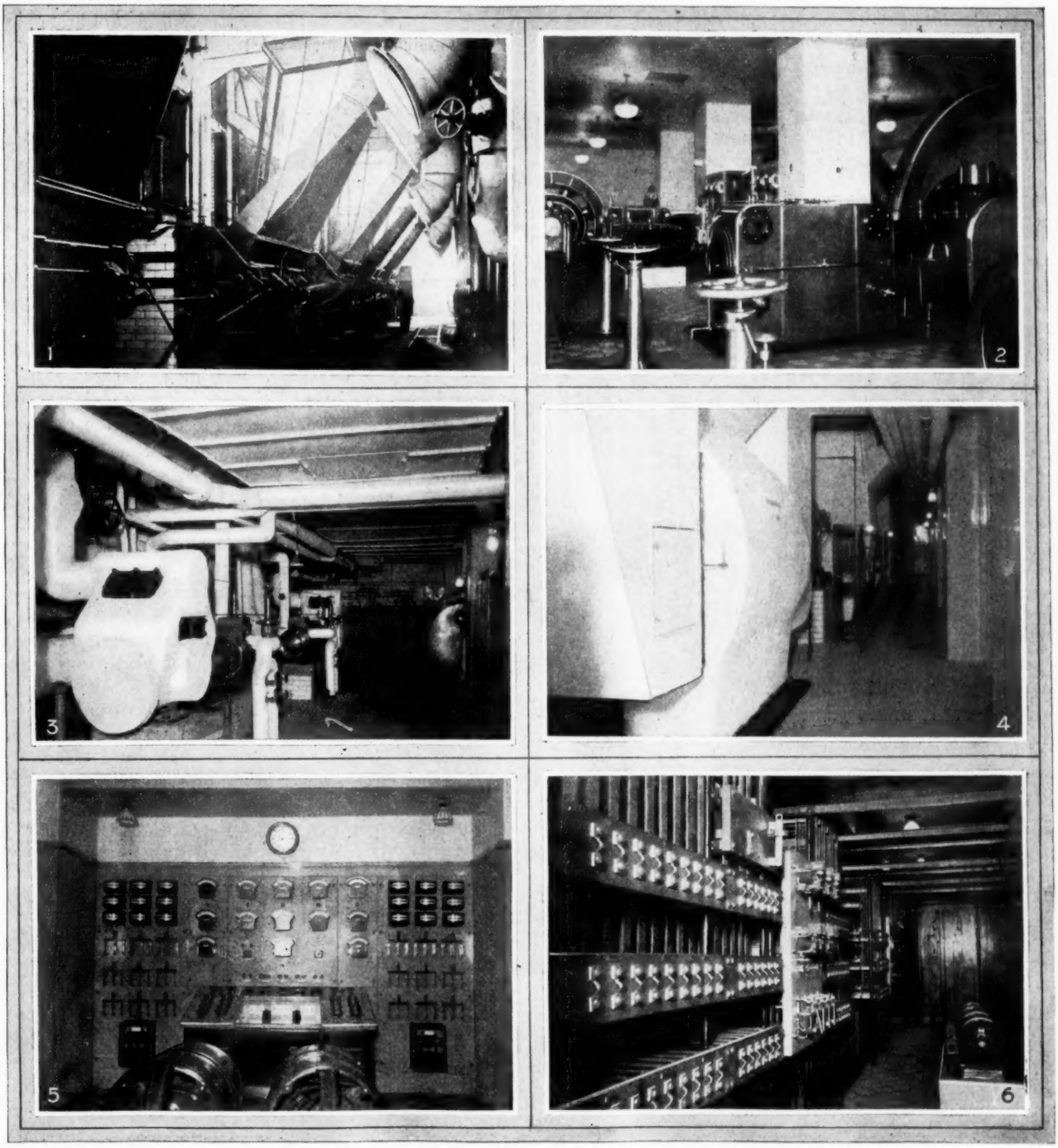
Another thing that strikes one as being an improvement in the general run of office-building power-plant design is the segregation of the various auxiliary apparatus in separate rooms, instead of being scattered promiscuously about the engine and boiler rooms. In a room at the rear of the boilers are the two simplex vacuum pumps, Fig. 3, that handle the returns and vacuum on the heating system. Low-pressure steam is used in a two-pipe system, and direct radiation is employed through the building with the exception of a few cases where indirect radiation is used. In general the heating is controlled automatically by thermostats for maintaining the desired room temperature, although in some instances modulation type of hand valves are used for regulation. The Johnson system of automatic heat control is used for special rooms and for public departments, as well as for the ventilating and heating coils of the ventilating system.

Natural ventilation is provided for the entire building with the exception of the twenty-sixth story (which is occupied by the company's executive offices), the first story and its mezzanines, and the basement, where artificial ventilation is used.

There are twelve motor-driven supply and exhaust fans. Four of the exhausters are grouped in a fanroom, Fig. 4, on a level with the engine room. All fresh air for ven-

tilating passes through cheesecloth filters, and the air supplied to the departments used by the public is washed for still further cleansing. In cold weather the air is passed over tempering coils. Six of the fans are used for supplying fresh air and six are for exhausting. The supply fans have a capacity of 185,000 cu.ft. of fresh air per minute; the exhausters have a capacity of 220,000 cu.ft. per min. The slow-speed motors driving these fans are of 20- and 27-hp. capacity. Both the engine and the boiler rooms are ventilated by a separate supply and exhaust fan, and these units are operated independently of the other fans used for ventilating the main building.

Twenty electric elevators of the Otis type are provided for passenger service. These are 1:1 gearless traction machines each having a capacity of 3000 lb. at a speed of about 600 ft. per min. Nine of these elevators travel between the sub-basement *A* and the twenty-sixth story, six between sub-basement *A* and the thirteenth story, four between the ground level and the twenty-sixth floor and one between basement *C* and the twenty-sixth floor. In the tower extending from the twenty-sixth to twenty-ninth floor there is also one electric elevator of 1200 lb. lifting capacity at 150 ft. per min. This elevator is provided with both automatic push-bottons and car switch



FIGS. 1 TO 6. VIEWS OF THE POWER PLANT OF THE AMERICAN TELEPHONE AND TELEGRAPH BUILDING

Fig. 1—Boiler room. Fig. 2—Engine room. Fig. 3—Vacuum pumps on heating system. Fig. 4—Fanroom. Fig. 5—Remote control switchboard. Fig. 6—Back of switchboard

control to be used as desired. All passenger elevators are equipped with telephones and operating, starting and signal equipment. Two of the passenger elevators are arranged for lifting safes and have capacities of 6000 lb. each. Three plunger sidewalk elevators with a capacity of 2000 lb. at 70 ft. per min. operate from the basement to the sidewalk. These machines are rope-controlled. Fig. 7 shows the 35-hp. motor-driven 8½ x 10-in. Deane triple-plunger pump that supplies water to the pressure tank at 180 lb. pressure. Another 4 x 8-in. motor-driven pump is piped direct to the elevator plungers when they are to be used for lifting heavy loads.

In the same room with these pumps are the pumps for handling the drinking water for the tenants, also the

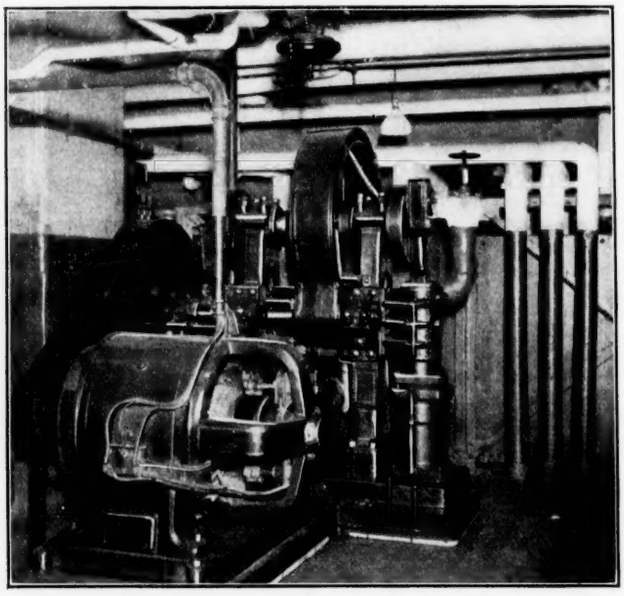


FIG. 7. MOTOR-DRIVEN PUMP FOR SIDEWALK ELEVATOR

16-ton Buffalo refrigerating machine for cooling the same. All water used through the building comes from the city mains and is filtered. All drinking water is further purified by passing through 24 Buhring water filters and is then pumped to a tank on the roof from which it flows to the brine-tank coils and is then circulated through the building by a motor-driven pump. Makeup drinking water is sent to the supply tank by a small direct-acting steam pump.

In the same room there are two 14 and 7 x 9-in. house pumps and one 22 and 10 x 18-in. fire pump. Besides these there are two Spencer turbine vacuum cleaners for general building service, a motor-driven air compressor to supply air for cleaning the generators and for blowing the soot from boiler tubes, no steam being used for this purpose.

As the basements are below the street-sewer level, four ejectors each with a capacity of 50 gal. per discharge are used. These operate with a float that actuates a weight arm that alternately admits and cuts on and off air at 60 lb. pressure to and from the ejectors as the sewage rises or falls when filling or discharging. Air is supplied by two 10 x 6-in. belt-driven compressors. All sump water is taken care of by either of two 9 and 8 x 10-in. duplex pumps.

All motor and lighting circuits are controlled from the switchboard shown in Fig. 5. This view shows only a part of the board, the motor-circuit panels being at the left and the lighting circuits at the right. The bench board is for remote control of the generator circuits, there being a circuit-breaker panel on the main floor at each generator. Leads from the generators are brought to these individual boards, and the circuit-breakers tie them to the busbars that are run in the basement below the generators. From this set of busses leads are brought to the switchboard for the distribution circuits. A view of the wiring at the back of the switchboard is shown in Fig. 6.

In a room at the rear of the switchboard there is a storage battery for emergency use. Provision has been made for guarding against failure of lights in the power plant by connecting the lighting circuits to the main busses. By this arrangement the power plant will be supplied with light as long as any one generator is in service. In case a total interruption to the electrical service should occur, the lighting circuits are automatically switched to the storage batteries. In case of an extremely long interruption, gas can be used.

The building was designed by William Wells Bosworth; Werner Nygren was the consulting engineer for steam power, heating and ventilation, and Henry C. Meyer, Jr., and Bassett Jones were the engineers for the electrical equipment.

Steam Turbines for Land Purposes

In a paper recently read before the Manchester Association of Engineers, H. L. Guy says that it has been established that a pure high-pressure machine is more efficient than a combination of a reciprocating engine exhausting into a low-pressure or mixed-pressure turbine, with the result that high-pressure turbines are being installed where the former types were adopted a few years ago. It is often a doubtful expedient to couple a new turbine to an obsolete or more or less wornout engine, which would in any case be scrapped long before the useful life of the turbine has expired.

Of the machines built in 1910, 46.8 per cent. ran at 3000 revolutions per minute, while of those built in 1915, 76 per cent. ran at this speed. The percentages of those running at 1500 r.p.m. were for 1910, 19.2, and for 1915, 15.2. The average output of each type was for the 3000-r.p.m. units 588 kw. in 1910 and in 1915, 1810 kw., while of the 1500-revolution machines the average capacity in 1910 was 2800 kw. and in 1915, 5300.

The continuous tendency toward increased output at high speed exhibited by these figures is responsible for many of the changes in design that have taken place. At 3000 kw. the steam consumption with a 3000-r.p.m. set is 6.15 per cent. better than at 1500 r.p.m., while the cost per kilowatt is 27.8 per cent. lower. For a 5000-kw. turbine the steam consumption at 3000 r.p.m. is 2.67 per cent. better than at 1500 r.p.m., and the cost per kilowatt 26.2 per cent. lower.

The output that can safely be obtained at a given speed and vacuum is limited largely by the last row of blades. If the length of blade be fixed, the volume of steam that can be passed through the last row can only be increased, and with it the output of the machine at a given vacuum, by increasing the velocity of the steam through the blades, which involves a sacrifice of kinetic energy, or what is called the "leaving loss." With a

factor of 3 based on the elastic limit, and a leaving loss of 1½ per cent., with nickel-steel blading, a turbine of 5000 kw. output can be built having a forked blade, or 3000 kw. with a dovetail blade. With phosphor-bronze the maximum output is 2250 kw. for a forked blade, and 1350 kw. for a dovetail blade. If the turbine having nickel-steel dovetail blades is rated at 5000 kw., the leaving loss, and therefore the steam consumption, will be 2.7 per cent. greater than with forked blades having the same factor of safety. For vacuums other than 28 inches the leaving loss varies as the square of the specific volume of the steam leaving the last row, so that the output for a given leaving loss varies approximately inversely as the square of the absolute pressure. The output that can be obtained with a given factor of safety and leaving loss varies directly as the strength of the material used for the blades and is independent of their mean diameter.

Practical Talks on Controllers—Series-Type Contactors*

SYNOPSIS—The construction and operation of a series type of contactor employing a lockout coil and the operation of a direct-current motor controller using this type of contactor are described.

In many of the installations made within the last few years involving motor-control apparatus, automatic self-starters of the magnetic-lockout switch current-limit type are encountered. This form of starter, while a trifle more complicated in principle of operation than some shunt-dashpot starters, does not present to the operating engineer or electrician any serious problem in adjustment and maintenance.

Self starters of this type, when used in connection with some form of remote-control device such as pressure regulators, float switches or push-buttons, are provided with a single-pole clapper-type main switch operated by a shunt-wound magnet and one or more accelerating or resistance switches according to the size of motor controlled. Fig. 1 shows a Cutler-Hammer direct-current motor starter of the lockout magnet type having two resistance switches *V*, one on either side of the shunt-magnet-operated main switch *M*. There is in addition a double-pole main-line knife switch *S* and two inclosed fuses *F*. The resistance switch *V* on the left is somewhat smaller than the one on the right, for the reason that it is the intermediate switch and is in circuit only during the accelerating period.

Fig. 2 shows the electrical connections of the accelerating switches *V*, Fig. 1. The switch, it will be observed, is provided with two series-wound magnet coils *P* and *Q*. These coils, when energized by the motor-armature current flowing through them, attract the movable member *E* of the switch. The upper coil *P* tends to close the switch, while the lower coil *Q* tends to hold it open. The air gap, or distance between the upper magnet-pole face and the movable member, is fixed, while the lower gap may be varied. By varying the lower gap while the upper one is fixed, the operation of the switch can be adjusted to suit different load conditions.

The functioning of the magnetic lockout switch, as described, is accomplished owing to the characteristic obtained by working two magnets at different points on the saturation curve, which in this case is equivalent to working one magnet under conditions of lower permeability than the other. It will be seen from Fig. 3 that the magnetic circuit of each of the series coils is independent of the other. The relative pull curves of the lockout and closing coils, from working one magnet under conditions of lower permeability than the other, is shown in Fig. 4. The lockout-coil pull rises continuously as the current is increased—approximately in proportion to the square of the current—while the pull of the closing coil rises rapidly for a short distance and then falls off materially in comparison with the rise in the pull of the lockout coil. It is obvious from this sketch that for current values which obtain below the point where the two curves cross, say at point *A*, the closing coil will overcome the pull of the lockout coil and close the switch, while current values in excess of that which obtains at the crossing point of the two curves will cause the lockout coil to overcome the pull of the closing coil and hold the switch member open.

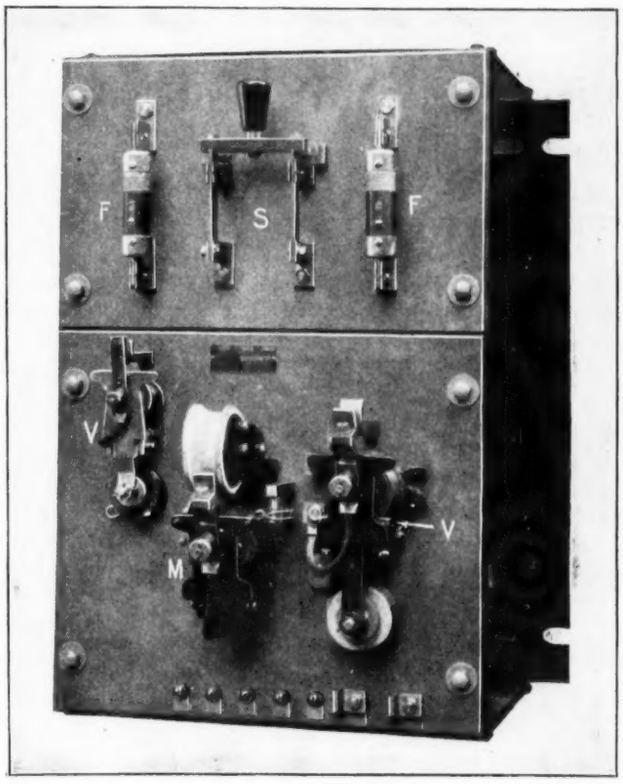


FIG. 1. DIRECT-CURRENT MOTOR AUTOMATIC STARTER EQUIPPED WITH LOCKOUT CONTACTORS

Fig. 5 is a wiring diagram for the type of controller shown in Fig. 1, connected to a shunt motor and operated by a float switch. A diaphragm pressure regulator or snap switch could also be used. Tracing the circuit from L_1 with the float switch closed, a circuit is obtained

*The material in this article was contributed by T. D. Montgomery, of the Cutler-Hammer Manufacturing Co.

through the series blowout magnet coil O to terminal L and the single-pole float switch to terminal C through the shunt-magnet coil operating the main-line switch M, the small flipper switch X and the resistance connected between the points B and S to L_2, thus completing the circuit to the magnet coil and causing it to close the single-pole main switch M. Closure of this switch causes the flipper switch X to be opened, thus breaking the direct path of the current through the resistance between B and S and causing the current to pass through the resistance connected between the points D and B and thence to the resistance between the points B and S to the line, as indicated in Fig. 6. It will be seen from this that the circuit to the magnet coil on the switch M is not interrupted, but after the switch X has been opened, the resistance between the points B and D is added to the circuit. The addition of this resistance to the circuit is for the purpose of reducing the current in the magnet coil after the switch is closed, thus reducing the heating.

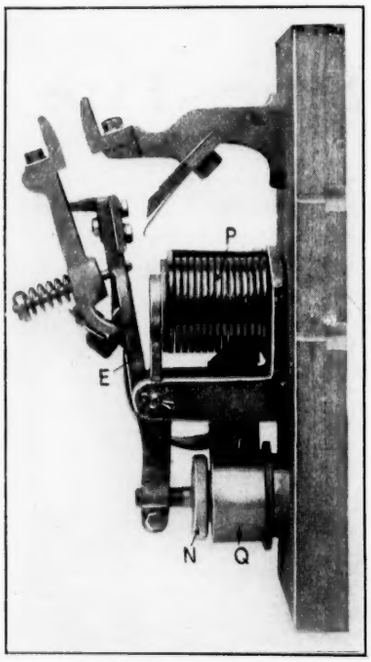


FIG. 2. SERIES LOCKOUT MAGNET SWITCH

Upon the closing of the single-pole main switch Fig. 6, the current passes from L_1 through the blowout coil O, the main switch M and the two series coils of the first accelerating switch V_1, then through the starting resistance connected between R_1 and R_4 to the A_1 terminal of the armature, through which it passes to L_2 as indicated by the heavy arrowheads. The field connection is taken from Y at the bottom of the main switch to F_1 through the shunt-field winding to L_2, as shown by the small arrowheads. The current through the series coils, of the accelerating switch V_1, causes them to be energized, but the switch does not close at once because the current is above the value for which the switch is adjusted to operate. When current is admitted to the armature, it should start to revolve, and as it increases in speed the current in the circuit will fall off due to the rise in the counter-electromotive force. When the current has fallen off to the value for which the first accelerating switch is adjusted to operate at, the switch closes, and in doing so provides a path for the current through the holding coil of the first switch, and the two coils of the second accelerating switch V_2, the resistance connected between R_2 and R_4 to the armature, as indicated in Fig. 7.

From the foregoing it will be seen that the resistance connected between R_1 and R_2 and the lower coil of the first accelerating switch are short-circuited. The short-circuiting of the resistance between R_1 and R_2 allows another inrush of current to the motor armature, causing it to speed up. The second accelerating switch V_2 does not close, however, until the motor speed is increased to the point where the current is reduced to the amount for which this switch is adjusted to close. The closing of the second accelerating switch accomplishes the purpose of shorting out its lockout coil and the resistance connected between R_2 and R_3 and at the same time provides a path for the current through the two series coils of the last accelerating switch V_3. Switch V_3 functions in the same manner as described in the foregoing for the other two accelerating switches, and upon suitable reduction of the armature current due to the increased speed of the motor it closes, providing a path for the armature current from the main-line clapper switch, through the upper coils of the accelerating switches and the armature to L_2, as shown in Fig. 8. This results in giving the motor full line potential and causes it to come up to full speed. The circuits which obtain when the three-wire normally open and normally closed push-button switches are employed are similar to the foregoing except that an extra maintaining circuit connected to terminal K and making contact when the main switch M, at the point K_1, is used. Closure of the normally open push-button X_1, connected between the terminals L and K, completes the circuit to the operating magnet of the clapper switch, as shown in Fig. 9. When the switch M makes contact at point K_1, the push-button X_1 is short-circuited so that when it is released and the path at that point broken, circuit to the magnet coil is maintained through the point K_1. As the normally closed stopping push-buttons are connected in the circuit through the magnet coil, depressing one of these buttons breaks the circuit and causes the magnet coil to be deënergized and the single-pole main-line switch member to be released, thus breaking the motor circuit.

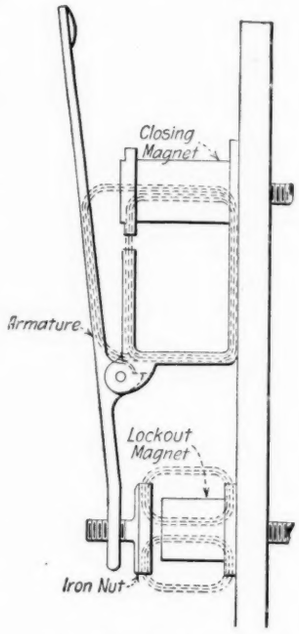


FIG. 3. MAGNET CIRCUITS OF LOCKOUT CONTACTOR

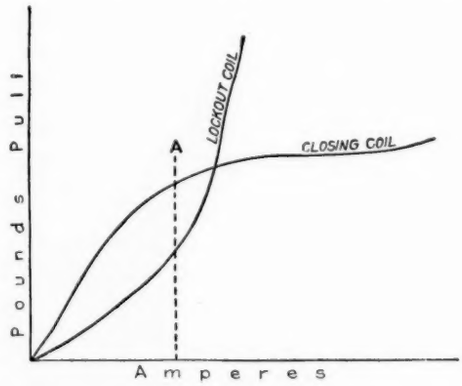


FIG. 4. RELATIVE PULL CURVES OF THE LOCKOUT AND CLOSING COILS

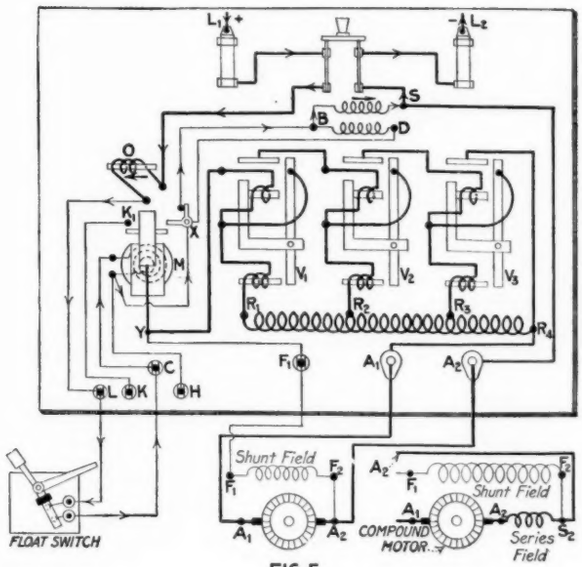


FIG. 5

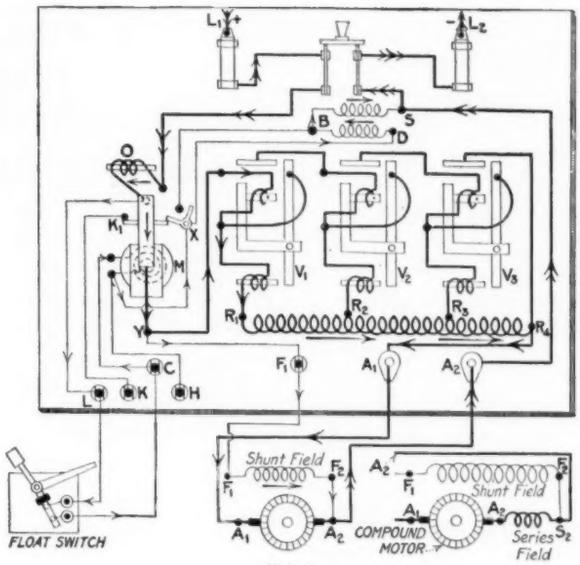


FIG. 6

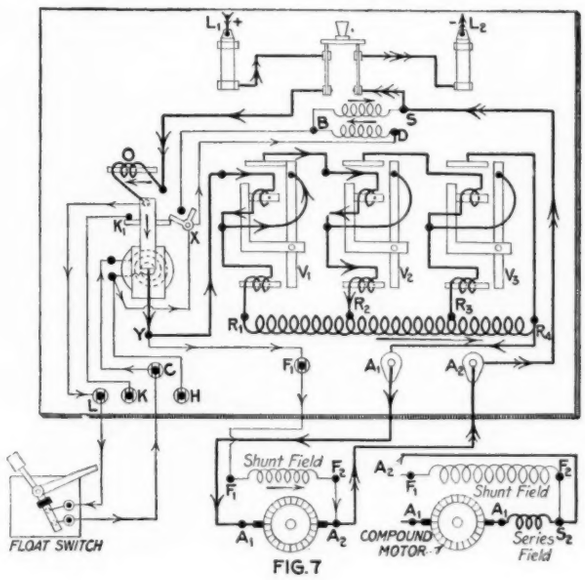


FIG. 7

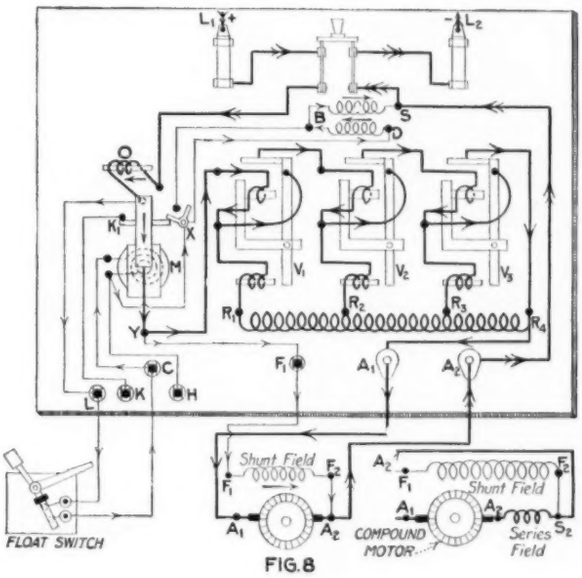


FIG. 8

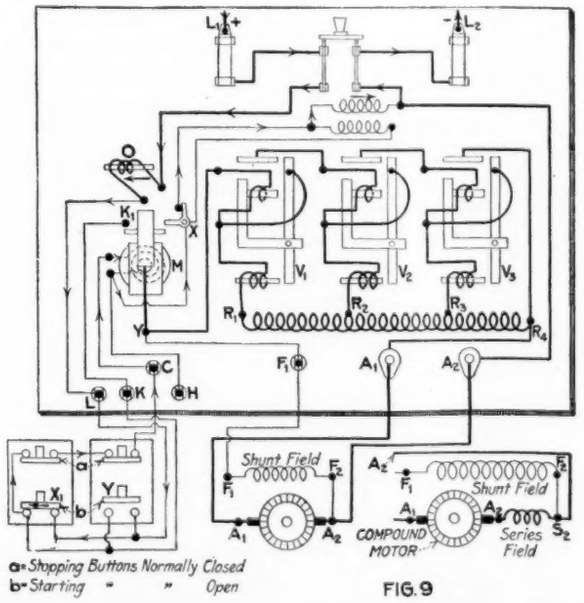


FIG. 9

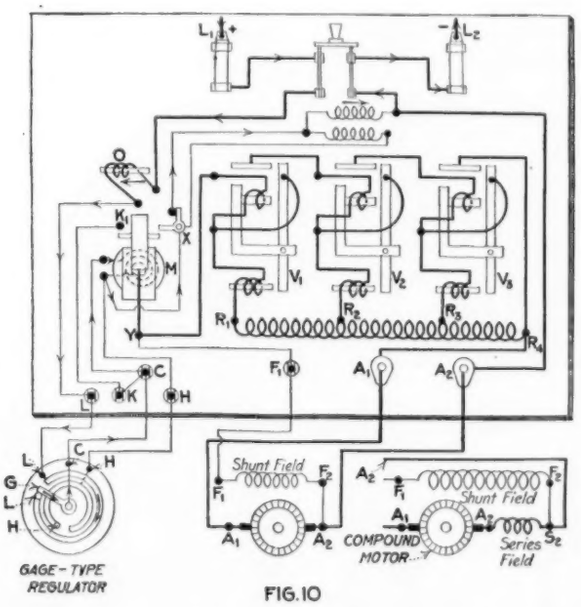


FIG. 10

FIGS. 5 TO 10. WIRING DIAGRAMS FOR A CUTLER-HAMMER LOCK-OUT CONTACTOR TYPE CONTROLLER

In order to use the gage-type pressure regulator, the contacts of which are somewhat delicate and not suitable for the breaking of a control current, it is necessary to utilize the maintaining circuit, as previously described, so that when contact by the indicator needle G is made between the points C and L, the circuit is completed through the magnet coil of the main switch, Fig. 10; this closes M, but when the needle breaks contact, no current has been broken for the reason that the circuit is maintained at the point K_1. In addition, the circuit completed by the connection to the terminal K is made use of in stopping, so that when the needle makes contact between the terminals C and H in the gage, a path for the current is provided around the magnet-coil terminals, thus shunting the current and causing it to be de-energized. The opening of the line switch M breaks the maintaining circuit and disrupts the circuit around the magnet coil so that when the needle in the regulator leaves its contact member H, no current is broken.

Characteristics of the Starter

From the foregoing it will be seen that if the starting load on the motor is very light, the inrush current will be practically equal to, or even less than, the lockout values of the accelerating switches, with the result that the tendency of these switches is to close immediately on the introduction of the current. The switches will therefore close rapidly with very little time allowed between them, and the motor is quickly brought up to speed. On the other hand, if the motor is heavily loaded, it will gain speed slowly and a greater length of time will be allowed for each succeeding inrush of current to drop down to the point where the following accelerating switch closes. Acceleration is therefore prolonged in keeping with the heavy load to be accelerated and very rapid in the case of light loads, which is entirely permissible.

With this form of starter it has been shown that the time of acceleration varies according to the variation in the load, and it follows that if the load is so heavy that it cannot be started with the current which the starting resistance permits to flow, acceleration cannot take place. Under such a condition a reduction in either the load or the starting resistance must be made.

It is further evident that though the load may start on the current which flows when the shunt main-line switch closes, it may be so heavy as to prevent the motor speeding up to the point where the current will drop below the lockout value for which the first accelerating switch is adjusted. As a result of this the motor will operate at reduced speed and both the motor armature and the starting resistance may become overheated. To cause the proper acceleration to take place under these conditions, the air gap of the first accelerating switch should be increased by adjusting the nut N, Fig. 2, thus permitting the first switch to close on a higher current value than originally adjusted for. Equivalent adjustment of the succeeding accelerating switches may be required if they fail to close, as necessary, to obtain proper acceleration.

Too rapid acceleration results from the switches being adjusted for heavier current than obtained from the load which is imposed on the motor, and as a consequence excessive accelerating peaks of current are produced and may cause the line fuses to blow or overload devices to trip. Decreasing the air gap of the accelerating switches will cause them to lock out on lower current values, with a consequent slowing down of acceleration.

If the motor fails to start when the shunt switch M closes, the cause may be excess load on the motor or an open circuit in the starting resistance. Should there be no evidence of heavy current being broken on the shunt clapper switch when it is opened and closed, either manually or by means of the control device, it may be assumed that the starting resistance is open-circuited.

To locate the steps in which the "open" exists, connect a test lamp in series with the motor armature and after closing the shunt switch M, close in order manually the accelerating switches. The lighting of the test lamp upon the closure of any one of the accelerating switches will indicate that the open circuit exists in the step immediately preceding the switch at which the lamp lights. By connecting the test-lamp terminals across the ends of each grid in the section where the "open" exists, the defective grid may be located by the fact that the lamp will not light when connected across it.

Armature Burned Out

By E. C. Parham

The cores of generator and motor armatures are built up of soft steel sheets called laminations. This construction is used to reduce the local currents, which would be considerable and cause excessive heating were the core solid. Breaking the continuity of the core with joints increases the resistance to eddy currents, but the resistance is further increased either by oxidizing the laminations or by giving them a coat of japan or insulating varnish. That the object of the laminated construction sometimes may not be appreciated is illustrated by the following experience:

The armature of a large continuous-current generator burned out on account of a ground due to lightning. On removing the damaged coils, it was discovered that a large hole had been burned into the core. The operator, who evidently considered that local repairs might safely be made without regard to laminated construction, went to considerable expense to machine the whole affected part of the core and to carefully dovetail into it a block of solid iron, into which had been milled slots for the armature coils. The armature was then rewound and replaced in commission, only to be burned out again in the same place after brief operation. The operator drew the correct conclusion as to the cause of the second failure; his second repair job was even more original than the first one and more effective. He removed the block of iron and inserted a wooden one. The coils then were repaired and replaced, and this makeshift construction proved to be satisfactory for the time being. Later, the only permanent method of making such a repair was adopted; that is to remove the defective laminations and reassemble that part of the core with new ones.

Mixture for Welding Steel—Ten parts of borax, one sal-ammoniac, pounded together and fused till clear, when it is poured out to cool and again powdered.

Frosted Glass, useful for screens, etc., is made by laying sheets horizontally and covering them with a strong solution of sulphate of zinc. The salt crystallizes on drying.

Condenser Performance

By H. A. Fisher

The effect that efficient performance of the condenser and its auxiliaries has on the over-all economy of the station has not attracted the attention of a great many engineers. Some seem to consider the condenser as a necessary evil, instead of a means of improving economy. In a great many plants the necessary instruments for measuring the performance are not provided.

In order to check the performance and detect any unusual condition, the condenser must be equipped with suitable gages and thermometers, located at the proper points. The ordinary vacuum gage is hardly sensitive enough for accurate results. However, a mercury column is not only accurate but foolproof and so inexpensive that no condenser should be operated without one. A mercury column can be made of a glass tube 32 in. or more in length, the lower end of which is to be immersed in a cup of mercury and the upper end connected to the exhaust pipe about halfway between the condenser and the turbine, or engine. A check valve should be placed in this pipe to prevent the mercury being blown out of the column should the condenser be subjected to a pressure. It is also necessary that the pipe leading from the exhaust pipe to the column be kept air-tight, as a very small leak in this pipe will cause an appreciable error in the readings. A barometer should also be provided. While not as essential as the mercury column, it is necessary if a complete check of the performance is wanted.

Thermometer Should Be Used on Condensers

A surface condenser should be equipped with four thermometers, one at each of the following points: Steam inlet, hot-well, circulating-water inlet and circulating-water discharge. It is also convenient to have one at the end of each pass.

Three thermometers are required on a jet condenser—at the steam inlet, the injection-water inlet and the injection-water discharge.

It is best to have thermometers permanently set, but if this is considered too expensive, thermometer wells may be inserted and the temperature measured with portable thermometers. Several of these should be provided, so that readings may be simultaneously taken at the different points. The thermometer wells should be partly filled with mercury. Lacking this, oil may be used, or if the wells are in a horizontal position and the temperature is not too high, they can be filled with grease.

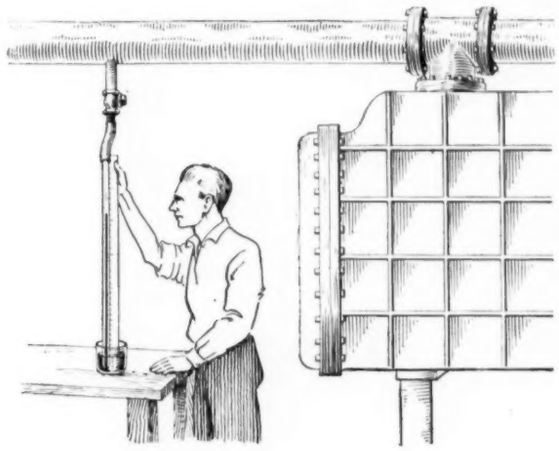
Readings of the load, vacuum, hotwell, circulating- or injection-water inlet and outlet temperatures should be taken at regular intervals and entered on a log sheet. These readings should be taken frequently enough to detect and check any unusual occurrence before it has gained much headway. (See "Calculations Show Air Leaks in Condenser," page 376, *Power*, Mar. 14, 1916.) With these readings before him, the engineer should be able to determine the cause of any unusual condition and take the proper steps to correct it.

The common ailments are air leaks, insufficient circulating or injection water, water too warm, poor air-pump performance, dirty tubes in surface condensers and obstructions in the nozzles of jet condensers.

Air-leakage tests may be made with a candle or torch by passing the flame over or close to the joints where leakage is suspected, while the condenser is subjected to a vacuum, or the steam space may be filled with water and an examination made for drips. Air leaks frequently occur at the expansion joint in the exhaust pipe, atmospheric relief valve, turbine and pump glands, the equilibrium pipes on reaction turbines and sometimes at sand holes in cast-iron fittings.

The impeller of the circulating pump should be examined occasionally to see that it is free from débris that would impair its efficiency, and it should be run at the proper speed and have a gage on the suction and one on the discharge line.

To get the best results the tubes in surface condensers must be clean. When surface condensers are used with



MERCURY COLUMN ATTACHED TO EXHAUST PIPE

engines or turbines receiving steam from engines, the steam side of the tubes should be examined, as they may become coated with oil carried over in the exhaust. Jet-condenser nozzles must be kept free of obstructions.

The importance of maintaining the highest possible vacuum with the condensing equipment and operating conditions at hand cannot be too strongly emphasized. While it is true that a greater saving is realized with turbines operating with a high vacuum than with reciprocating engines, considerable increase in the economy of an engine can sometimes be made by raising the vacuum, as shown by careful tests made at the Fifty-Ninth Street Station of the Interborough Rapid Transit Co., New York City. A decrease of 8 per cent. in the steam consumption of the engines was the result when the vacuum was raised from 25 to 28 in. (Kent's "Mechanical Engineers' Pocketbook," under "Advantage of High Vacuum in Reciprocating Engines.") This is equivalent to a little more than 2.5 per cent. decrease in steam consumption per inch rise of vacuum.

With the steam turbine the decrease in steam consumption may be from 3 to 8 per cent. per inch increase of the vacuum. This may vary somewhat with different sizes and types. The following percentages are given in Kent (1916 edition): 5 per cent. for each inch between 24 and 27 in., 6 to 7 per cent. between 27 and 28 in. and 7 to 8 per cent. between 28 and 29 in.

The foregoing applies to high-pressure turbines. The effect of a change in vacuum on a low-pressure turbine is about twice as great as in a high-pressure machine.

Foundations and Foundation Plans

By D. O. Barrett

SYNOPSIS—The author upon investigation found that there is little attempt on the part of builders to carry a constant relation between horsepower and volume of foundation through the various lines of oil engines. After discussing the question he describes the design of foundation finally adopted for a line of engines ranging from 20- to 150-hp. capacity.

The two requisites for a successful oil-engine foundation are, first, sufficient weight to absorb the vibrations incident to the power stroke, and second, the area of the bottom of the foundation must be sufficiently large to properly support both the foundation and the engine.

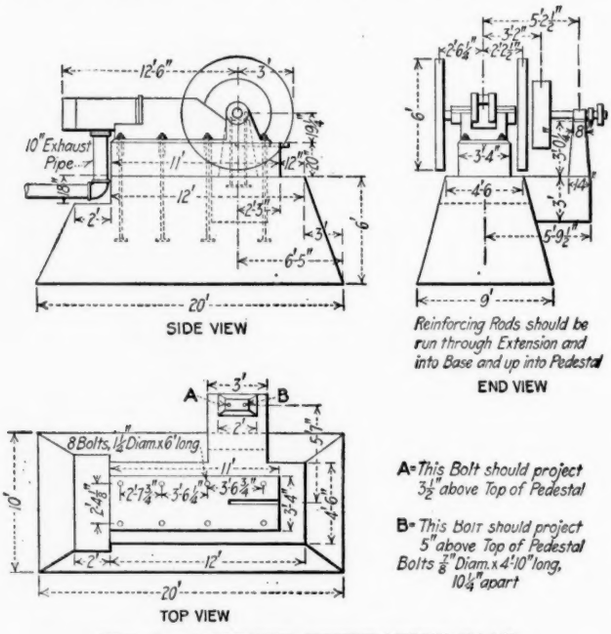

SIDE VIEW
END VIEW
TOP VIEW
Reinforcing Rods should be run through Extension and into Base and up into Pedestal
A-This Bolt should project 3½" above Top of Pedestal
B-This Bolt should project 5" above Top of Pedestal
Bolts ⅞" Diam. x 4'10" long, 10¼" apart
8 Bolts, 1½" Diam. x 6' long

FIG. 1. ADOPTED FOUNDATION PLAN

This latter requirement is of course dependent upon the character of the soil encountered. The weight of the foundation is dependent upon the type of machine to be installed, as an extremely high-speed engine would require a much smaller foundation than a slow-speed unit of the same power. This article will consider engines of from 20 to 200 rated horsepower of the horizontal type, with rotative speeds varying from 300 to 175 r.p.m., and with piston speeds of from 600 to 800 ft. per minute.

The writer was recently called upon to redesign and lay out foundation plans for a complete line of engines of the two-stroke cycle, heavy-duty type, burning crude oil and ranging from 20 to 150 hp. Considerable trouble had been experienced in various ways by those installing the engines, and it was also found that some of the smaller sizes had foundation plans calling for nearly 100 per cent. excess volume when compared with the larger powers. Many of these outfits had also been installed with an outer bearing for supporting the clutch shaft and many of these supports had been put in with no connection to the main foundation, with the result that they were soon out of line and giving a great deal of clutch trouble.

Before proceeding, an investigation was made of all the foundation plans that were available (and these included many complete lines of engines) in an effort to determine just how these were proportioned for the different makes. A careful study revealed that there seemed to be no effort on the part of designers to carry a constant relation through the entire line. When the volume of the foundation was made a function of the rated horsepower, it was found in many instances, that as the engines increased in size this ratio also increased and in other cases exactly the reverse was noted. In fact, there was practically no similarity between any of the different makes, and it was found that some of the lighter engines, having high rotative speeds, were provided with much larger foundations than many of the slow-speed, heavy-duty type. It was evident that the greater number of these foundations had been drawn up merely to suit the fancy of the designer and quite unrelated to any other sizes of the same make.

Taking the volume of the foundation as a function of the rated power, we have

$$V = xH \qquad (1)$$

where

V = Volume of foundation in cubic feet;
x = A constant;
H = Rated horsepower.

It was found that in some cases the value of the constant x ran as high as 12.5, while in others it was as low as 4. Taking several complete lines of engines, the following average results were obtained for x: 4.8; 6.5; 6.7; 8.7; 9.4; 10.2; 11.6. In order to get an intelligible working value for the constant, the various values were plotted with respect to the rated power and an average value then assumed. This gives a constant value for all sizes, and it may be possible that, theoretically, this should vary with the power, but for practical purposes this need not be considered. The value thus obtained was 7.5, so that we have

$$V = 7.5H \qquad (2)$$

Güldner gives the following values for x:

Horizontal engines without outboard bearing	14 to 18
Horizontal engines with outboard bearing	21 to 25
Vertical engines without outboard bearing	7.7 to 8.8
Vertical engines with outboard bearing	9.8 to 10.5

These figures of course apply to Continental practice and also include the largest sizes of engines; the values are much larger than those prevailing in this country.

Hænssgen gives the following:

Four-stroke-cycle, single-acting, horizontal	14
Four-stroke-cycle, double-acting, horizontal	11
Two-stroke-cycle, single-acting, horizontal	8
Two-stroke-cycle, double-acting, horizontal	6
Giving an average value for the two-stroke-cycle motor of about	7

Theoretically, the rotative speed of the engine should be taken into account as well as the weight, and the following formula, taken from Roberts' Handbook, contains these two factors:

$$W = 0.21w\sqrt{R} \qquad (3)$$

where

W = Weight of foundation in pounds;
w = Weight of engine;
R = Speed of engine in revolutions per minute.

This formula is faulty in that it does not take into account the fact that two engines of the same rated power and running at the same speed may vary in weight between wide limits; actual examples show this variation to be as great as 50 per cent., which would thus affect the size of the foundation in the same ratio. Since the foundation weight is a function of the square root of the number of revolutions, this factor may vary within wide limits without greatly affecting the size.

Assuming the unit weight of concrete as 140 lb. per cu.ft. and substituting in formula (3), we have

$$V = 0.0015w\sqrt{R} \qquad (4)$$

Among the various makes of engines the ratings, in proportion to the actual piston displacements, may vary as much as 50 per cent., and the writer determined a value based upon the product of the square of the bore multiplied by the stroke, this being proportional to the piston displacement per revolution. After plotting the various values obtained from actual calculation, an average value of 0.12 was chosen in the equation,

$$V = 0.12B^2S \qquad (5)$$

where

B = Bore of cylinder, in.;

S = Stroke of piston, in.

Here again, a discrepancy was noted between the different makes; for instance, an average value for a line of extremely heavy engines was only 0.088.

The three following formulas were then taken as representing standard practice:

$$V = 7.5H \qquad (2)$$

$$V = 0.12B^2S \qquad (5)$$

$$V = 0.0015w\sqrt{R} \qquad (4)$$

In calculating the volumes of the foundation for the line of engines previously mentioned, these three formulas were all used and the average values then adopted. In order to better show a comparison from the three methods, the table gives the results for four sizes.

It will be noticed that the values obtained from the third formula containing the factor R are considerably less than those from the other two, in the larger sizes. This is due to the fact that the weight per horsepower decreases as the power increases. Then, too, the value of R is also decreasing with the increase in power. Should the rating of the engine bear a constant relation to the piston displacement, the values obtained from the first two formulas would be the same.

FOUNDATION VOLUMES FOR OIL ENGINES

Rated Horsepower	Bore, In.	Stroke, In.	R.P.M.	Weight of Engine, Lb.	V = 7.5 H. Cu.Ft.	V = 0.12 B²S. Cu.Ft.	V = 0.0015 w√R. Cu.Ft.	Volume Selected, Cu.Ft.	Weight of Volume Selected	Weight Foundation / Weight Engine	Area of Foundation, Sq.Ft.	Dimensions of Foundation, Ft.
H	B	S	R	W	V_1	V_2	V_3	V	W	$\frac{W}{w}$		
25	10	15	275	7,800	188	180	194	185	25,900	3.32	52	5x10
40	12	16	250	12,400	300	277	297	290	40,600	3.28	82	7x12
60	14	18	250	18,500	450	443	438	445	62,300	3.37	125	8x16
110	18	24	210	33,000	825	933	720	850	119,000	3.61	224	10x22

The weights of both engine and foundation are given in the table, and they bear a somewhat constant ratio to each other, although increasing with the rated power. We might, then, express the weight of the foundation in terms of engine weight, omitting the factor R, having

$$W = (3.3 \text{ to } 4.5)\ w \qquad (6)$$

The factor would vary between rather wide limits, being controlled, as before explained, by the ratio existing between the engine weight and the rated power. The variation, however, is no greater than with some of the other factors and may be intelligently used if the weight per horsepower of the engine be taken into account. Values as determined from the formulas and then averaged will give foundations of ample size for normal conditions, running somewhat larger than those proposed by many firms. Where abnormal conditions exist, the size of the foundation must be intelligently increased to conform to local requirements.

Fig. 1 shows the style of foundation plant adopted. Both the sides and the ends of the foundation were given

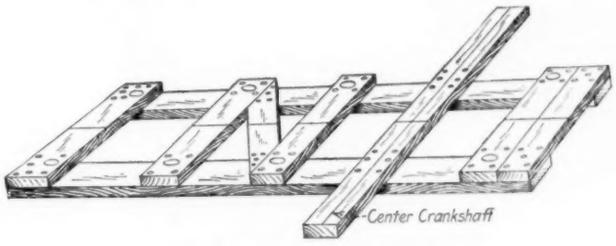


FIG. 2. FOUNDATION TEMPLET

an ample batter, for two reasons—to increase the area of the base as well as its length and also to take advantage of the weight of the soil which rests on the sloping sides. Of course the labor involved in building forms for the sloping sides is slightly more than where left straight but the maximum efficiency is obtained for a given weight of material used. The sides and ends might also be made in a series of steps securing practically the same results Wherever it was possible for a dimension to be confused or a mistake to occur, the actual dimension was omitted and a note placed at the side giving the correct distance, so that it was practically impossible for this important point to be overlooked.

Regarding the area of the foundation at the bottom, this of course depends directly upon the character of the soil. For ordinary soil Güldner gives an allowable pressure of 45 lb. per sq.in. and for soft clay and fine damp sand, 15 lb. This of course includes the weights of both foundation and engine. However, in none of the foundations encountered by the writer have these values ever been approached. It is good policy to make the bottom of the foundation as long as possible in order to counteract any tendency to rock back and forth. In the figures given in the table, the areas of the bases were calculated on a basis of about 650 lb. per sq.ft., or approximately 5 lb. per sq.in. In the larger sizes this may run as high as 800 pounds.

The writer has seen many foundations put in where it was necessary to chip off the bosses on the engine bed in order to get a nut on the foundation bolt. Dimensions were of course given correctly on the original plans, at least from a drawing-office standpoint, but in such a manner as might easily confuse the layman. In the plan adopted a note is given at the side for this important point, so that a mistake can hardly occur. Additional notes also give instructions for increasing the size of the foundation under certain conditions, such as wet or extremely loose soil. One often sees engines

rocking back and forth where this feature has been overlooked, and attempts to tie these up by the use of a concrete floor or other means to the side walls or to the building foundations do not give much relief and will often cause other aggravating troubles. Any supports for outer bearings should be carefully tied to the main foundation, as the strain put on such members by clutch shafts that are out of line is often enormous.

Another feature generally overlooked is that of painting the upper part of the foundation to protect it from the deteriorating influence of oil, which will gradually soak in and cause the outer surface to crumble away. A coating of pure cement should be rubbed on with a trowel before the foundation becomes thoroughly dry and, after installing the engine and before running, should be painted. Any oil that runs down may then be wiped off without leaving an unsightly spot. Another point that adds to the finished appearance of the job is to allow at least one-half inch for raising the engine off the top of the foundation and then, after leveling up, to carefully work in a stiff mixture under the edges and filling the bolt holes, running this from the outer edge of the concrete base up to a line an inch or two above the bottom of the base casting of the engine. This gives the engine the appearance of being set into the concrete and no doubt helps to hold it more solidly to the foundation.

Bolt-Hole Dimensions

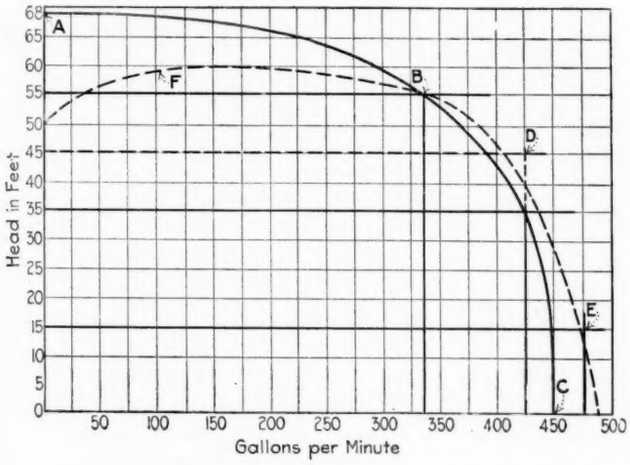
All dimensions for bolt holes are given from the center of the crankshaft or from the center line of the cylinder, so that the engine will properly line up with other machinery. The end foundation bolts should always be placed well back from the end, where possible; should the nuts come loose at any time, the engine may move sufficiently to break off the ends of that portion above the floor. The bolts should extend to about two-thirds the depth of the concrete. Thinking to make the engine more solid on the base, the novice will sometimes cement in the exhaust pipe and elbow. In no case should this be done, as the expansion and contraction of the pipe will simply crack the concrete and loosen itself and a strain will also be placed on the cylinder, tending to lift it. Again it may be necessary to remove the exhaust pipe, and sufficient space should be left around it so as to be readily accessible.

The proper locating and lining-up of the engine depends largely upon the correct construction and lining-up of the templet which is used to space and hold the foundation bolts while the concrete is being poured around them. Of course some allowance is always made by the use of short pieces of pipe or wooden boxes around the bolts, which may be filled with cement when the engine is finally in place. Ordinarily, the construction of this templet is left to the man who is to install the engine, obtaining the necessary dimensions directly from the regular foundation plan, and with proper care, no trouble will occur, but to secure the best results, it is better to have the templet constructed at the factory or else to have a drawing showing the exact construction. Such a templet is shown in Fig. 2. Since the foundation bolts are usually shipped from the factory, the templet may be sent at the same time. It should be made to the outer dimensions for that part of the foundation extending above the floor and on which the engine rests. The forms for this portion may then be built directly onto the templet. The long cross-piece on which is marked the center line of the crankshaft is cut to the correct length, so as to indicate at one side the center of the clutch pulley and at the other the center of the flywheel. The center line of the cylinder should also be carefully marked to enable lining up with existing machinery. Templets of this character should always be solidly built and well braced, so that they will not become distorted by careless handling before reaching their destination.

Centrifugal Pump Hints

By F. Webster

To operate a centrifugal pump so as to get the most work out of it is more of a job than the simplicity of the pump would indicate. The machine is capable of producing a lot of surprises. Some of these are: Failure to deliver water either against a standpipe head or on open nozzle; it may stop drawing water; a change of head either high or low may give unlooked-for results; it may get hot pumping cold water; the shaft sometimes gets scored in the stuffing-boxes; the motor may



CAPACITY CURVE OF CENTRIFUGAL PUMP AT 1000 R.P.M.

get "stuck" when the head is considerably lowered; and a combination of circumstances may operate all at once and effectively give the double-cross to the operator.

The operator has nothing to do with the design of the pump, but if he knows why it is designed so and so, and if he has a copy of its characteristic curve, he will have a wonderful advantage when the pump takes one of its tantrums.

As a general thing the foundation for a centrifugal pump need not be as heavy as that for a direct-acting steam pump. The suction pipe should be as direct and short as possible and one or two sizes larger than the pump inlet. There should be a foot valve and a strainer at the bottom of the suction pipe, and the free opening through these ought to be from two to four times that of the pipe. The slots through the strainer should be narrower than the smallest passage in the impeller so as to catch materials that might clog the pump. A good style of foot valve is one having a double gate hinged at the sides and opening from the middle. The vacuum gage should be close to the pump inlet, and when the pump is operating properly, this gage will register anywhere from 3 to 7 in. of vacuum. If the strainer clogs

or if the water flows faster than about 10 ft. per sec., causing too much air to enter and friction loss, etc., the gage may show 15 in. or more.

The discharge pipe ought to be larger than the pump opening. Install a gate valve and a check valve near the discharge with suitable drains, priming pipes, etc., and a pressure gage. Always close the gate valve before starting and before stopping. All centrifugal pumps must be primed, and this should be done before starting, otherwise there is danger of heating and expanding the impeller and injuring the pump. Do not prime by means of the gate valve in the discharge, but use a separate system.

Pack the stuffing-boxes with a soft graphite packing of square form. The circular-form packing is objectionable as it sometimes wears grooves in the shaft. Ordinary hemp packing is worthless for centrifugal pumps.

One of the most useful possessions of the operator of a centrifugal pump is what is known as the characteristic curves of the pump. This shows the relationship of the capacity, speed and head. Such curves are made by the builders when the pump is tested before shipment, and they are generally furnished on request. A study of these curves will show the operator what to expect, and they will aid him in solving many a mystery. A typical set of curves is shown in the illustration.

Two lines *OA* and *OC* are drawn at right angles, and each is marked off in equal spaces to any convenient scale. The horizontal scale represents gallons per minute delivered by the pump, and the vertical scale gives the head in feet. The pump from which this curve was made was operated by an electric motor at 1000 r.p.m., which is its designed standard speed. The greatest head given by the impeller was 68 ft., and this was when no water was delivered. The greatest water flow, 450 gal. at *C*, was produced when there was no head, the pump outlet being open on the level. At any intermediate point, as at *B*, 330 gal. flowed at a head of 55 feet.

Now suppose that there is a demand for, say, 425 gal. at 45 ft. head. In this case the ordinates from the respective points on the scales meet at *D* outside the characteristic curve *ABC*, showing that the pump will not fill these conditions. Nor will it deliver 475 gal. at a 15-ft. head, as at *E*.

Besides the capacity curve, the pump builders construct curves for the efficiency and the horsepower. The power increases with the water flow, even with a great reduction in the head, and operators often get stuck when attempting to change the head and capacity. When the load on the pump is mainly the weight of the water —that is, the friction is small, as for irrigating, emptying basins, etc.—a very little drop in the speed will stop the flow. On the other hand, if the piping is extra long so as to make a high friction, as in the case of condensers, mining work, etc., a considerable variation may be made in the speed of the motor without stopping the flow.

Sometimes the design of the pump is such that its delivery is very unstable, and if the operator is not posted on its characteristic curve, he may have considerable trouble in getting the work out of the pump. For example, its curve may be like the dotted line *F*. This shows that the head rises from 50 ft. to *F* as the flow increases from zero to 150 or so, or through quite a range, and then diminishes. As the head at starting is only 50 ft., the pump may not be able to start against the head *F* of a filled standpipe without having its speed above the normal.

Another method is the use of a bypass to take off the static head. An unstable pump is liable to stop flowing from either a varying motor speed or head.

Visits of Inspector Brown—XXVII

By J. E. Terman

SYNOPSIS—The Chief gives further instructions on the subject of diagraming formulas, ending with a stay-bolt diagram.

"Come in, Brown," said the Chief, as Brown stuck his head in the doorway. "I suppose that you have come to continue the subject of diagraming formulas and to see if we can't get to that stay-bolt formula."

"Yes, Chief, that is just what I would like to do," said Brown.

"Well, there is just one more stunt that I want to show you in connection with the juggling of a formula so that it may be represented by a straight line," continued the Chief, "and that is, when you have a formula like this,

$$y = \frac{a}{x} \qquad (1)$$

you may represent it by a straight line for any particular value of a, without resorting to the use of logarithms, by using the reciprocal values of x instead of the direct values of that variable. For instance, formula (1) may be written $y = a\left(\frac{1}{x}\right)$, and you will see at once that if the $\frac{1}{x}$ on the right side of this equation is the variable, that it is of the same form as $y = ax$.

"One of the advantages of adopting this means of getting a straight line from such a formula is the ease with which the reciprocals may be laid off without calculation. We will take up the question of laying off reciprocals graphically shortly. Another advantage about this method, that is not obtained by using logarithmic paper, is that a formula such as $y = a\left(\frac{1}{x}\right) + b$ also becomes a straight line. In our last talk I showed you that such a formula could not be represented by a straight line by means of logarithmic paper. To be sure that you understand how to make a diagram of the formula $y = \frac{a}{x}$ by using reciprocal values, it will be best to make such a diagram.

"Suppose, Brown, that the values of x in formula (1), in which we would be interested for the purpose of making a diagram, should range from 4 to 10, and that the corresponding values of y were from 2 to 5, and that the value of a was 20. The first thing you should remember is, that the larger a number the smaller its recipro-

cal, and that if a number was of infinite size its reciprocal would therefore be zero. Since the positions of values of x are to be represented to correspond to the values of the reciprocals of that variable rather than its direct values, the position of the y axis, which would represent zero as a direct value of x, would represent infinity as a reciprocal of x. This is just like a Chinese method of doing the thing, for instead of starting with the position of the y axis representing a zero value of x and increasing

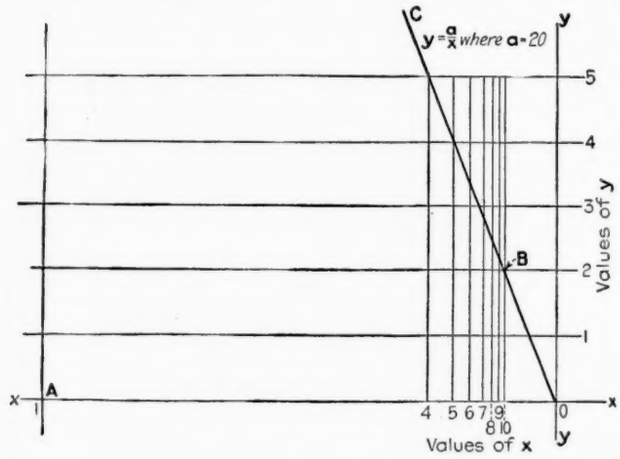


FIG. 1. DIAGRAM WITH AXIS Y PLACED AT THE RIGHT

as we proceed to the right, we start with the biggest value for x, as being represented by the position of the y axis, and the values of x decrease as we go away from the y axis.

"In order to have our diagram not entirely Chinese—that is, to be read from right to left—the axis of y must be placed at the right instead of at the left. Here, you will see that I have placed the y axis in this position," and the Chief showed Fig. 1.

"Since the values of x in which we are interested in making this diagram are to range from 4 to 10, if the position of the vertical at A on the left represents a value of 1 to the scale of our diagram, then the position of a value of $x = 4$ will be at a point one-fourth of the distance from O to A, or at the vertical marked 4. The position of 5, 6, etc., will be at points $\frac{1}{5}$, $\frac{1}{6}$, etc., of the distance from O to A from the point O.

"In an actual diagram there is no need for the portion lying to the left of the vertical marked 4, because we started out with the understanding that only values from 4 to 10 for x would interest us. All that remains to make this sheet practical for the purpose of diagraming formula (1) is to locate horizontal lines evenly spaced to represent the values of y, as I have done." (See Fig. 1.)

"Why, I can see that is a whole lot better and simpler than using logarithms," said Brown.

"Returning to our original formula," continued the Chief, "$y = \frac{a}{x}$, if x is an infinitely large number, the right-hand side of the equation becomes zero; for if any finite number such as 20 is divided by a number having an infinite value, the result will be zero.

"Thus our equation becomes $y = 0$, which indicates that all lines representing this formula for different values of a pass through the intersection of the x and y axes, just the same as in the case of formula $y = ax$. This fact makes it necessary to find only one other point on any line representing a particular value of a, in order to draw it. Such points may be found by assuming any fixed value for x, such as 10, and by substituting this value in the formula, it is seen that the corresponding value of y would be 2, where a has a value of 20. The position of this point I have located here at B (Fig. 1) and the line BC, drawn through B and O, will represent all values given by the formula $y = \frac{a}{x}$, where a has a value of 20."

"Gee! that looks fine, Chief, but what has it to do with the diagraming of that formula giving the pitch of stay-bolts, as used in the Code?"

"I will admit that this subject has been rather long drawn out Brown, but you will now understand why we have taken so long to finally come to the point of actually diagraming this code formula," said the Chief.

"You will notice that the Code formula for spacing of stay-bolts, is

$$P = C \times \frac{t^2}{p^2}$$

where

P = The maximum allowable working pressure in pounds per square inch;
p = The maximum pitch for the stay-bolts;
C = A constant, the value of which is changed for certain differences in plate thickness.

For stay-bolts screwed through the sheets and ends riveted over, C has a value of 112 for plates not exceeding $\frac{7}{16}$-in. thickness, and for plates in excess of $\frac{7}{16}$ in. thickness the value of C is 120.

"Before starting to diagram a formula of any kind," continued the Chief, "you first want to study the formula to see how it may best be represented by straight lines, and carefully consider just what factors should be considered constant to make the diagram best suit the purpose for which it is intended. In this stay-bolt

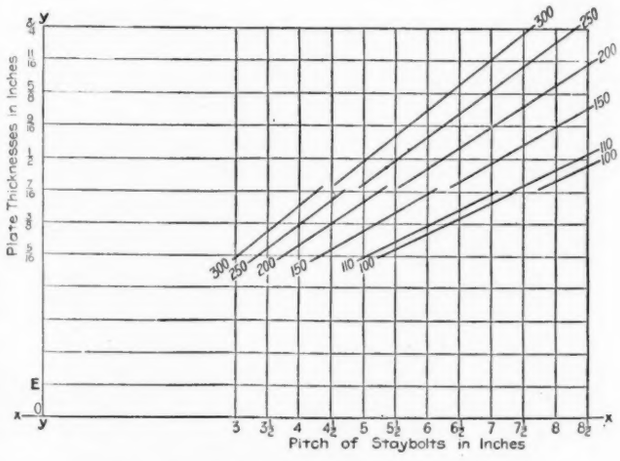


FIG. 2. DIAGRAM FOR STAYBOLTS

formula there are three variable factors besides the constant C, and in order to make our diagram, one of these three variables must be considered constant for each particular line of the diagram. That is, there must be a line to represent each particular value of either P, t or p. If P is to be considered a constant—that is, if we are to have a different line on our diagram for each value of P to be considered—then the stay-bolt formula could be written,

$$p^2 \frac{P}{C} = t^2 \qquad (2)$$

You will see that this formula may be represented by straight lines, without any juggling, on account of the reasons I explained to you during our last talk. That is, formula (2) is the same as $p\sqrt{\frac{P}{C}} = t$, which, of course, is a straight line when the values of P and C are constant. All the lines representing the different values of P will pass through the intersection of the x and y axes, just the same as in the case of $y = ax$. I have drawn a diagram representing a few different values for P, in the manner we have discussed just to show you how it could be done." (See Fig. 2.)

"You will notice a break in the diagram just above the $\frac{7}{16}$-in. line; this is because the value of the constant C changes for plate thicknesses over this amount. If you intend to use this method for making a diagram of the Code values for stay-bolt spacing, you should use two different positions for the intersection of the x and y axes for the different portions of the diagram, to avoid confusion of the lines. That is, let O (Fig. 2) represent the intersection of the axes for the portion of the diagram for plates not exceeding $\frac{7}{16}$ in. thickness, and let the horizontal at E represent the position of the x axis for the top portion of the diagram. Then E would be the intersection of the axes for this upper portion.

"If this plan is followed, the horizontal lines representing $\frac{1}{2}$, $\frac{9}{16}$ and larger values of plate thickness would be moved up just one line above their present positions here" (Fig. 2).

"Using this method for making the diagram would produce a real break between the $\frac{7}{16}$-in. and the $\frac{1}{2}$-in. plate-thickness lines. All pressure lines in the lower portion of such a diagram would pass through O, and the pressure lines in the upper portion would pass through E.

"Well, it is 5 o'clock, Brown, and I haven't signed a single letter yet. Come in again when you have time, for there is still something left that I want you to know regarding diagraming this stay-bolt formula"; whereupon Brown returned to his desk.

The Electrical Study Course—Parallel Circuits

SYNOPSIS—The problem given in the last lesson is worked out and then methods of calculating the joint resistance of parallel circuits are discussed.

The study problem given in the lesson on series circuits is shown in Fig. 1. The first step in the solution is to find the total resistance. In the last lesson we found that the total resistance of two or more resistances connected in series was equal to the sum of the individual resistances. Hence in Fig 1, $R = R_1 + R_2 + R_3 = 5.5 + 9 + 2.5 = 17$ ohms. The current $I = \frac{E}{R} = \frac{235}{17} = 13.824$ amperes.

$E_1 = R_1 I = 5.5 \times 13.824 = 76.03$ volts.
$E_2 = R_2 I = 9 \times 13.824 = 124.42$ volts.
$E_3 = R_3 I = 2.5 \times 13.824 = 34.56$ volts.

The value of I by using the volts dropped and the resistance of each section is $I = \frac{E_1}{R_1} = \frac{76.03}{5.5} = 13.824$ amperes; $I = \frac{E_2}{R_2} = \frac{124.42}{9} = 13.83$ amperes; $I = \frac{E_3}{R_3} = \frac{34.56}{2.5} = 13.824$ amperes.

The sum of the volts dropped across the three sections is $E = E_1 + E_2 = E_3 = 76.03 + 124.42 + 34.56 = 235.01$ volts, against 235 volts given. Voltmeter A will read 76.03; B, 124.42; C, 34.56, and D, 235 volts. Both ammeters F and G will read the total current, or 13.824 amperes. In practice the instrument could not be read much closer than the even values given, or the next higher.

The most common method of grouping different devices on an electric circuit is to connect them in parallel. In Fig. 2 is shown a simple circuit consisting of a single element R_1 connected to a source of electromotive force. The strength of the current for the value of volts and resistance given is by Ohm's law, $I_1 = \frac{E}{R_1} = \frac{180}{15} = 12$ amperes, as indicated. If a second resistance, R_2, of 15 ohms is connected across the circuit, as in Fig. 3, there will also be 12 amperes passing through this path, making a total of 24 amperes flowing in the main circuit. That is, 24 amperes will flow from the positive terminal of the generator through the ammeter to R_2, 12 amperes flowing through R_2 and the other 12 through R_1 around to the negative terminal of R_2, where the two currents join and flow back into the negative terminal.

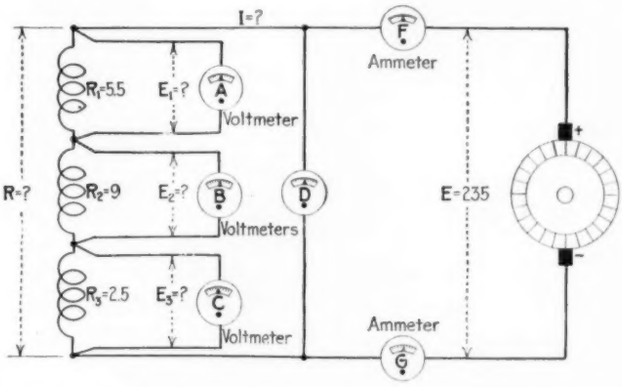


FIG. 1. CIRCUIT CONSISTING OF THREE RESISTANCES CONNECTED IN SERIES

Fig. 4 shows a hydraulic analogy of Fig. 3, where the intake and discharge of a pump are connected to two large pipes, which are connected together by several small pipes. If the system is full of water and only valve No. 1 is open, a current of water will flow depending upon the size of this pipe and the pressure. Open valve No. 2, and if this pipe is the same size as No. 1, double the amount of water will flow if the pressure is maintained constant. That is, a given quantity of water flows down pipe A, one half of it passing through connection No. 1

and the other half through connection No. 2, where the two currents join and flow back through B to the pump; this is identical to the flow of the current in Fig. 3.

The total resistance of any circuit is equal to the total voltage divided by the total current. In Fig. 3 the total resistance is $R = \frac{E}{I} = \frac{180}{24} = 7.5$ ohms. It will be seen that this value, 7.5, is one-half that of R_1 or R_2. In other words R = either R_1 or R_2 divided by 2, the number of resistances in parallel, in this case two. This is true in all cases where equal resistances are connected in parallel. The joint resistance of the group is equal to the resistance of one circuit divided by the number of circuits in parallel, or $\frac{20}{5} = 4$ ohms.

Referring again to Fig. 4, if by opening valve No. 1 six gallons per second flows around through the system, when all valves are open, if all pipes are the same size, five times six, or 30 gallons per second would flow through the system. In this analogy the pressure has been assumed to remain constant; therefore, if five times as much water flows in the circuit under the latter condition as under the former, the resistance of the path must have been reduced by five. But the resistance offered to the flow of each individual path in Fig. 4 has not been changed. Likewise in Fig. 5 the resistance of each individual circuit has not been changed; the combination of the five equal resistances in parallel only produced an

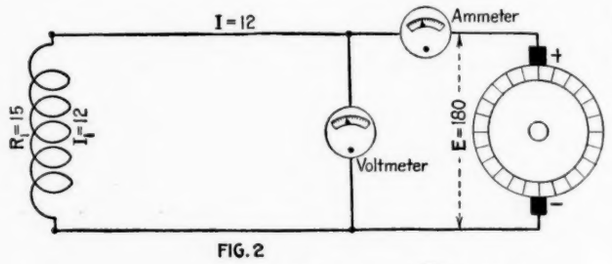


FIG. 2

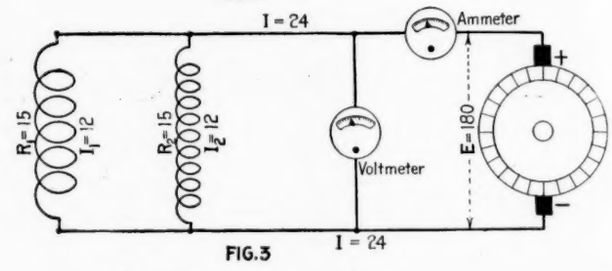


FIG. 3

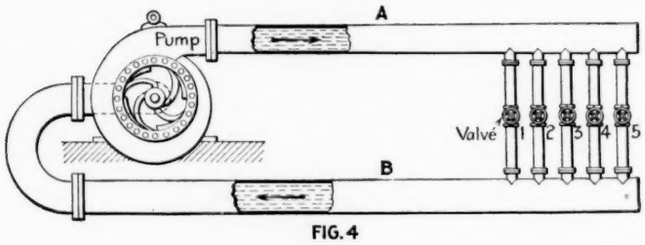


FIG. 4

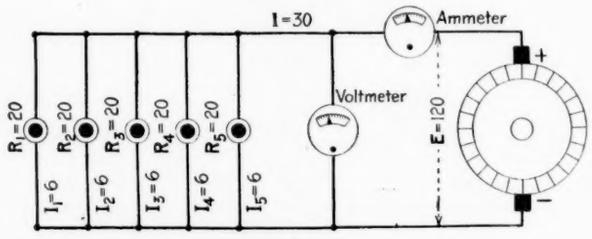


FIG. 5

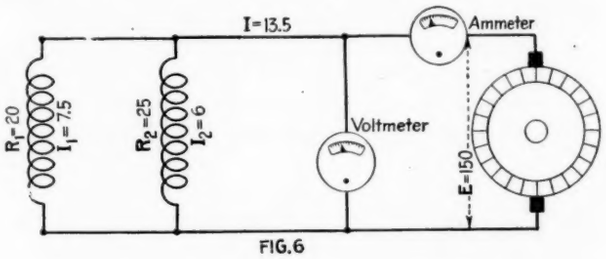


FIG. 6

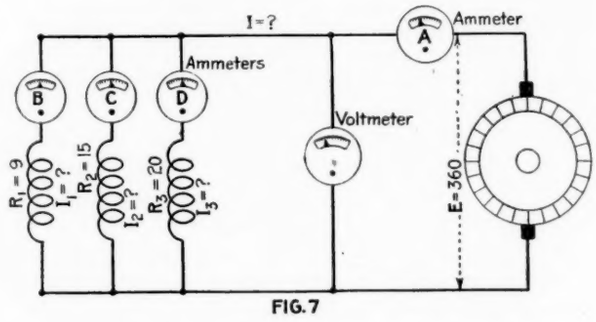


FIG. 7

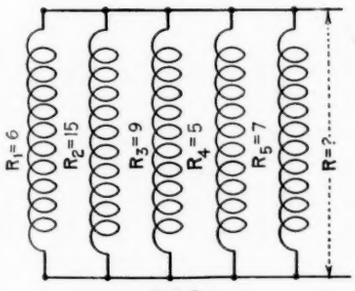


FIG. 8

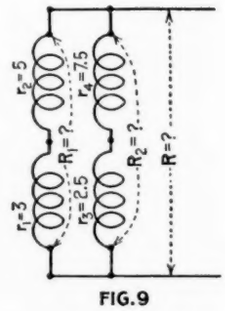


FIG. 9

FIGS. 2 TO 9. ILLUSTRATE THE PRINCIPLE OF PARALLEL CIRCUITS

to the resistance of one of the individual circuits divided by the number connected in parallel.

To further illustrate this problem, Fig. 5 is given; here five lamps of 20 ohms each are connected across a 120-volt circuit. By Ohm's law each lamp will take $I = \frac{E}{R_1} = \frac{120}{20} = 6$ amperes. Then the total current will equal the sum of that in each circuit, or 30 amperes. The joint resistance is equal to the total volts divided by the total current. In this problem the joint resistance $R = \frac{E}{I} = \frac{120}{30} = 4$ ohms. The joint resistance is also equal

equivalent resistance, equal to that of one divided by the number in parallel, or in this case one-fifth that of one individual circuit.

From the foregoing it is evident that the problem of calculating the joint resistance of a circuit made up of a number of equal resistances connected in parallel is a simple one. However, when the resistances of each individual circuit are not equal, a different method must be employed. One way of obtaining the joint resistance of a circuit composed of two or more unequal resistances in parallel would be to assume a given voltage applied to the circuit and then apply Ohm's law; finding the value of the current that would flow in each circuit for this

voltage, and then finding the joint resistance by dividing the voltage by the total current.

In Fig. 6 are shown two resistances, R_1 and R_2, of 20 and 25 ohms respectively, connected in parallel across a 150-volt circuit. The current passing through R_1 is $I_1 = \frac{E}{R_1} = \frac{150}{20} = 7.5$ amperes, and in R_2 is $I_2 = \frac{E}{R_2} = \frac{150}{25} = 6$ amperes. The total current equals $I_1 + I_2 = 7.5 + 6 = 13.5$ amperes, and the total resistance R, equals the total volts E divided by the current I; that is, $R = \frac{E}{I} = \frac{150}{13.5} = 11.11$ ohms.

In reference to the flow of electricity, all substances may be considered as possessing two properties—first, the property which opposes the flow of an electric current (resistance), and second, the property that allows the flow of, or conducts, an electric current, called conductance. In any material, if the resistance is high conductance must be low, or conversely, if the resistance is low the conductance must be high. The relation of the resistance to the conductance of a circuit is expressed as follows: If R represents the resistance of a circuit, the conductance will be represented by $\frac{1}{R}$, and is usually expressed, the conductance is equal to the reciprocal of the resistance. Then in Fig. 6, where $R_1 = 20$, the conductance of this circuit will equal $\frac{1}{R_1} = \frac{1}{20} = 0.05$ mhos; $R_2 = 25$, then the conductance of this circuit will equal $\frac{1}{R_2} = \frac{1}{25} = 0.04$ mhos. The name mho, ohm spelled backward, has been proposed for the unit of conductance.

The total conductance of a circuit is equal to the sum of the conductances connected in parallel. Then in the problem, Fig. 6, conductance $= \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{20} + \frac{1}{25} = \frac{5+4}{100} = \frac{9}{100} = 0.09$ mhos. Since conductance is the inverse of resistance, resistance must be the inverse of conductance, that is, resistance $= \frac{1}{\text{conductance}}$. Therefore in this problem the joint resistance, $R = \frac{1}{\text{total conductance}} = \frac{1}{\frac{9}{100}} = \frac{100}{9} = 11.11$ ohms, which is the same as obtained by Ohm's law.

The foregoing method of finding the joint resistance may be expressed by a formula. We have just seen that the conductance of a circuit consisting of several resistances in parallel is, conductance $= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \cdots$ depending upon the number in parallel. The resistance R being equal to $\frac{1}{\text{conductance}}$ may be expressed as $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \cdots}$. Applying this to our problem, $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{20} + \frac{1}{25}} = \frac{1}{\frac{9}{100}} = \frac{100}{9} = 11.11$, the same as obtained by the other two methods of working the problem. The foregoing expression will be known in the future lessons as the joint-resistance formula.

The study problems are given in Figs. 7, 8 and 9. In Fig. 7, in addition to finding the values indicated by the question mark, find the joint resistance of the circuit by Ohm's law, check the result by the joint-resistance formula and indicate what each ammeter will read. In Fig. 8 find the joint resistance R, and in Fig. 9 find the resistance of each circuit R_1 and R_2 and the joint resistance R of the group.

Bull-Ring Repair Job

By W. T. Osborn

An engine gave trouble by steam blowing past the piston. Upon examination it was found that the bull-ring was worn $\frac{1}{4}$ in. To repair it in a machine shop would cost

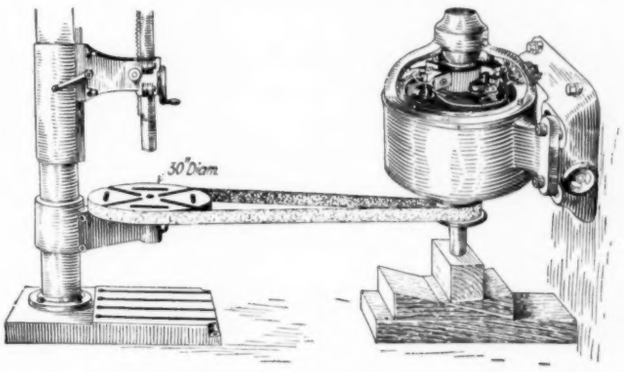


FIG. 1. EMERGENCY ARRANGEMENT OF MOTOR AND DRILL PRESS

about $300, which was considered too high. The largest lathe in the factory had only a 12-in. swing. A friend of the engineer got around the difficulty in the following manner: A drill press with a 30-in. table was among the shop equipment. The table was removed, cleaned and graphite put in the bearing so that it would run freely. An old motor with a flange pulley was lined up with the table. The oil was drained out of the motor bearings, and it was then secured to the wall by expansion bolts. The shaft was blocked up with wood and taper wedges from

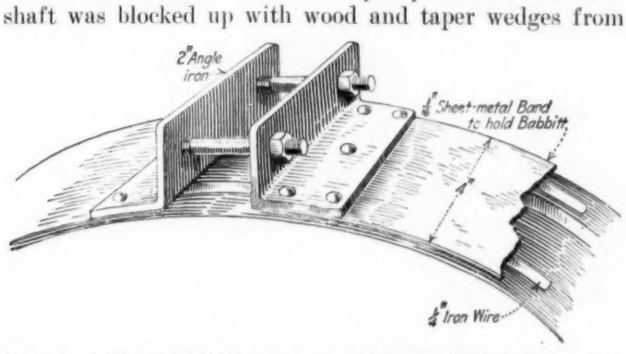


FIG. 2. SHEET-IRON BAND FOR BABBITTING BULL-RING

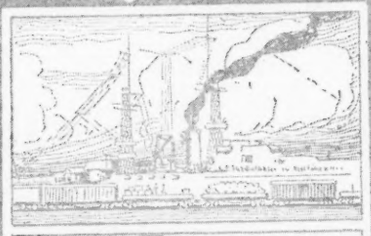
the floor. The motor and table were connected by a 2-in. belt, Fig. 1, and a boring bar was placed in the drill-press spindle.

The bull-ring, which had been rebabbitted by pouring the metal inside a 4-in. wide sheet-iron band elevated by $\frac{1}{4}$-in. wire, Fig. 2, was then secured to the drill-press table and, with the table revolving, was turned to the proper size. This improvised turning job has effected a saving of five tons of coal per week.

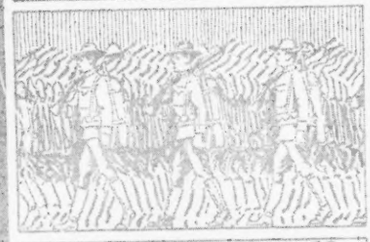
THE NEW ALLY

By Berton Braley

We enter the war with the other democracies of the world, including our Canadian Brethren, not so much to "beat up" Germany as to make a new earth where peace may be safe and democracy assured. America fights, not for material gain, but for principle.

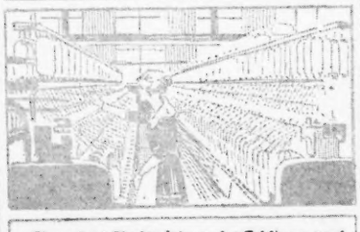


Putting our Navy on War Footing

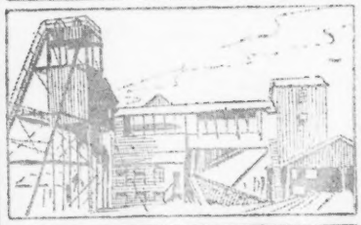


Creating and Equipping a Great Army

We must supply abundant Food for ourselves, our Armies and our Seamen



Abundant Materials out of Mines and Factories to Clothe and Equip our Forces



Coal to keep the Fires going in Ships at Sea

Cheer up, Tommy Atkins and Johnny Crapaud,
Your road has been weary and bloody, we know;
You've fought through discouragement, sorrow, defeat,
When failure seemed certain and gloom was complete;
But always our hearts and our prayers were with you
And now all our wealth and our power are too;
We've picked up the sword, and we've laid down the pen
And Uncle Sam's coming with millions and men!

Our vessels shall come to you loaded with grain,
So many the U-boats will fight them in vain;
From mills and from shops, from farms and from mines,
Munitions and foodstuffs shall come to your lines;
And soon we shall send, with our steel and our guns,
A million or so of our gallantest sons;
We'll help to bring peace to the world once again
With Uncle Sam's millions and Uncle Sam's men!

We hate all the bloodshed and horror of war,
But freedom and justice are worth fighting for;
And therefore we join with your battle-scarred clan
To make the world safe for the future of man;
Fight on, brother nations, be steadfast of heart,
We're coming to join you and take up our part,
To fight till democracy conquers again
With Uncle Sam's millions and Uncle Sam's men!

Editorials

Wake Up America!

Russia has undertaken the stupendous task of transforming itself, in the middle of the greatest war in history, from the most autocratic and reactionary to the most liberal and democratic country on earth.

Can she do it and still maintain her pressure on the Central Powers?

Our hearts and our hopes are with the new government, and eyes and ears are strained for tidings of its welfare; but with what difficulties may it not be beset!

And if it fails! Yes, even if it has to divert its energies to coping with an internecine foe, how grave may be the issue! With the pressure from the East removed, especially with a separate peace declared which would raise the blockade, what might not the Central Powers do when they faced about and directed all their renewed resources at the western line!

And in the meantime the ruthless destruction on the ocean goes on with growing effectiveness. Unless we can disable U-boats faster than we are doing, or furnish prey for them faster than Germany can destroy it, the Allies may be hamstrung.

It is far less improbable than many events which these fateful two years have developed that we may find ourselves fighting Germany alone; not an exhausted, broken, bankrupt Germany, but a triumphant, war-hardened, efficient Germany, with her own released and the acquired British navy bearing upon our defenseless shores to reimburse her depleted treasury from our accumulated wealth.

This is pessimistic, but possible.

The only way to avoid it is to strike now, and strike hard, and strike as an aroused and united people. There must be no more hope held out to the enemy through misguided or Teuton-inspired effort to hamper our advance. If we had been building ships a year ago, instead of listening to the love-one-another lullabies of those who would in the next breath palliate the massacre of the Armenians, the danger would be over now. May we not have cause to regret still more the time that we have lost in getting into our khaki? From now on brand every man who by voice or vote impairs the unanimity of our offensive, every man who by shirk or sneer retards the impetus of our coöperation, a coward or a traitor. If you would not fight when the perfidious war god broke his kingly word and planted his foot on inoffensive Belgium; if you would not fight when skulking Might destroyed the "Lusitania," if you would have supinely submitted when ordered off of God's free ocean, if, when desperate plotters came to incite friendly nations to stab you in the back, you would have mildly deplored the perfidy; if the honor and fair name of your outraged nation is nothing to you; if President Wilson's plea for the perpetuation of democracy and the right of the weak to walk amid the strong harmless and unafraid did not move you—wake now and lend a helping hand lest you may have to fight a conquest-drunken swashbuckler in your night clothes.

If you cannot, will not fight, do what you can—eat less, raise more, do more. Every useful thing you do in peace is of more consequence in war. Even a fighting world must live, and those who do not fight must earn the living and furnish the sinews. On our Foreword page is announced the $7,000,000,000 war loan. Do you realize what it means? If $240 were contributed every second, it would take nearly a year to raise it. If $1,000,000 were contributed every working day, it would take nearly twenty years to accumulate it. But we have wealth, if we have not ships, and guns, and soldiers, and money must be our first contribution. The loan amounts to $70 for every man woman and child in the country, and the man of moderate means must furnish much of it. Rich men's properties are in securities, the wholesale liquidation of which would unsettle our whole industrial and financial fabric. The bonds will be in small denominations and will be safe, interest-bearing and tax free. Telephone to your bank today that you want as many of them as you can carry. The moral effect of an overwhelming contribution to this Liberty Loan will be greater at this particular time than that of the offer of a dozen battleships.

Technical Paper Number 137

There is every reason to believe that Technical Paper 137 of the Bureau of Mines will be received as one of the most valuable contributions from that department on the subject of combustion. Intense interest was shown when Professor Lionel S. Marks outlined the contents of the paper before a recent joint meeting of the Boston Sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and had there been opportunity for discussion some very interesting comment on this paper might now be available.

The disappearance of all free oxygen, at four inches above the grate in a six-inch thick fuel bed, and the highest temperature and highest CO_2 content occurring at approximately the same distance—namely, four inches above the grate—will surprise many. We have a vague recollection that D. K. Clark, in one of his engineering volumes, brought out essentially the same information.

The reader must bear in mind when reading this paper that the fuel used was sized, that it consisted of pieces passing over one-inch mesh screen and through one and one-half inch screen. The density throughout a fuel bed of such coal is of course considerably more uniform than in a fuel bed under boilers in commercial operation, where the green coal particles are usually anything from dust to large lumps. The resistance at various places in the commercial fuel bed, and therefore the combustion rate and the rate of reactions at various places, must be widely different from those obtained in the experimental fuel bed despite the fact that the green coal in the latter, and in any fuel bed for that matter, breaks up as volatilization and combustion proceeds. It is this condition,

therefore, that must qualify the statement that, "with a six-inch fuel bed the oxygen in the air rising through the grate is all used up in combustion in the first four inches from the grate." This condition also must qualify the statement that ". . . " about one-half of the fifteen pounds of air used to burn one pound of coal in a boiler furnace is supplied through the fuel bed; the other half must be supplied over the fuel bed."

At the surface of the experimental fuel bed the combustible gases reached from twenty to thirty-two per cent. This affords one of the best technical arguments for high boiler settings yet advanced. It means that one can appreciate, because of the definiteness of the figures, the necessity of not only getting sufficient air in above the grate, but getting it there in finely divided streams well distributed; and it shows the value of furnace volume great enough to obtain a thorough mixture of air and combustible gases.

The experiments also show that ash fuses in the upper layers of the fuel bed, usually in a reducing atmosphere.

Carbon Lamp Versus Tungsten Lamp Renewal Service

In the United States today there are some seventy cities, which have a population of forty thousand each and over, aggregating a total of approximately eight and a half millions, where the central stations are still supplying carbon lamps free, not considering those cases where carbon lamps are furnished free and tungsten lamps offered at reduced rates, where no lamp service is given at all, or the vast number of cities and towns having a population of less than forty thousand. Nor are there included in these figures the cities where carbon lamps and tungsten lamps of 100 watts and over are supplied free, making it impossible for the residence-lighting customer to take advantage of the free renewal of tungsten lamps.

When consideration is given to the length of time that the tungsten lamp has been in use, its high economy and the comparatively small difference in the cost of the two lamps, it does not seem possible that the carbon lamp could be in such wide service today unless there is some powerful interest promoting its use.

There is no particular reason why a central station should give a free lamp service, or any as far as that is concerned, but when a utility takes such a responsibility upon itself, there is no just reason why the most economical lamps should not be supplied. The subterfuge of rendering the public a service under the disguise of free renewal of carbon lamps is something that is costing each customer that uses these lamps approximately three times what it would for the same candlepower if tungsten lamps were used. Is this a free renewal lamp service, that is costing the customer dollars that can be purchased for cents? Probably some of those who advocate carbon lamps can show where the great economy is obtained by producing energy under the most economical conditions and utilizing it under the most uneconomical.

Early in the development of the tungsten lamp several of the central stations took a very active part in recommending them to their customers and for a number of years have been refusing to supply carbon lamps under any condition and urging their customers to use the most economical lamps for their purpose. Such a position by a utility is highly commendable and indicates a willingness on its part to render its customers a just and adequate service.

The Bureau of Standards, Washington, D. C., has just issued Circular No. 55 on the use of tungsten lamps, in which it points out that the tungsten lamp has been improved in quality and reduced in price to such an extent that no customers could afford to use carbon lamps even if they were paid a bonus on each lamp for doing so. The bureau gives its earnest approval to a wider use of tungsten lamps as a measure of economy and calls the public's attention to this important subject by emphasizing the fact that the cost of a lamp is reckoned in cents, but the cost of energy to operate it during its life is a matter of dollars. The energy cost for a tungsten lamp is only about one-third that of the carbon lamp of the same candlepower.

In the Bureau of Standards Circular No. 56, "Standards for Electric Service," there are suggested effective rules for adoption by municipal and state public-service commissions and recommendations "that each utility supplying electricity for incandescent lighting should render its customers reasonable assistance in securing the incandescent lamps and other appliances best adapted to the service furnished; that lamps furnished by utilities to customers without charge (free renewals) or at prices less than open-market prices should be of such efficiency in watts per candle, when used on the utility's circuits of standard voltage, so that customers may obtain their lighting service under the most favorable conditions practicable under the rate schedule."

The bureau is to be commended for its efforts to adequately inform the public of the importance of using tungsten lamps. Here is an opportunity for utility commissions to render the public an important service by coöperating with the Bureau of Standards in its educational work along this line.

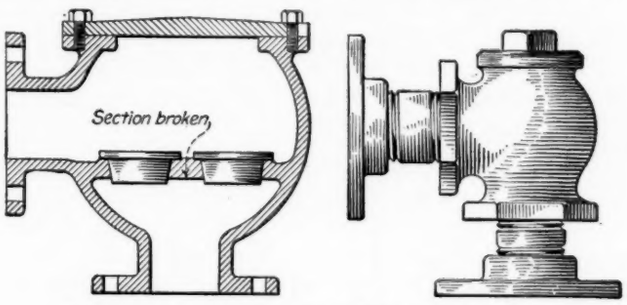
No doubt, during the present international crisis many of the central-station carbon-lamp advocates will find their plants hard-pressed for capacity to supply the demand of the many new industries that will come into existence to provide the country's needs. By seeing to it that the carbon lamps supplied from their plants are replaced by tungsten, considerable additional capacity can be obtained, which will not only allow supplying industries that will be in pressing need of power, but will also afford the electrical manufacturers an extension of time on deliveries of equipment, so that they may give more attention to the needs of the nation. Furthermore, these central stations will be taking an important step toward the conservation of our fuel supplies.

The cancelling, after all arrangements had been completed, of the National Electric Light Association convention which was to have been held in Atlantic City the end of this month and the substitution on short notice of a two-day meeting in New York on May ninth and tenth to consider the immediate problems concerning the needs of the Government and the electrical industry is evidence of the important role that the production of power will play in the great conflict. While many will be disappointed at the change in plans the officers of the association are to be congratulated on their patriotic action.

Correspondence

Temporary Repair to Feed Pump

The valve chamber of a duplex plunger pump failed and was replaced temporarily with an angle check valve and piping made up as shown in the illustration. The



VALVE CHAMBER REPLACED WITH ANGLE CHECK VALVE

valve deck was cracked between the seats and various methods had been tried to repair it without success. The water could be heard blowing. The section temporary connection was made up of two flanges, two nipples of the right length to make the centers the same, and an angle check valve. Although it was of a smaller area than the area of the valves in the chamber, the pump ran as well as usual. After the new chamber arrived, it was taken off and saved for use in case of another such occurrence. The pump had eight such chambers and was pumping from a heater at about 200 deg. F., delivering boiler-feed water at about 180 lb. pressure. G. HART.

Homestead, Penn.

Water in the Ammonia Charge

The article on "Water in the Ammonia Charge" in the Mar. 6 issue of *Power* is an example of lack of information on ammonia on the part of many engineers. In operating the refrigerating machine there are several principles requiring special consideration: The ammonia charge must be ample; the liquid ammonia must be pure; the system must be free from foreign gases.

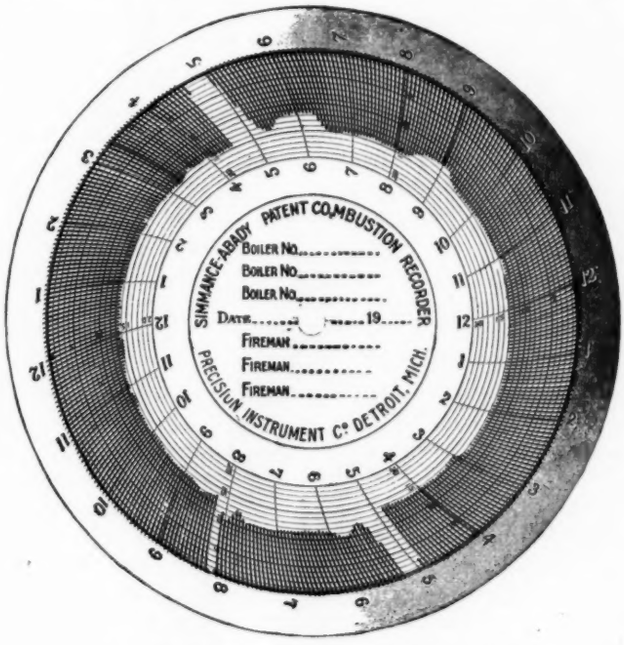
The first is checked by having a gage-glass on the receiver or by noting the noise in the expansion valve. The difference between the flow of a liquid and a liquid with gas can be differentiated easily. The second is a regulation test and should be performed at stated intervals. Water in the liquid ammonia results in the formation of aqua ammonia, which requires a lower pressure for the same boiling temperature as that of the ammonia, the result being a loss of capacity and difficulty in securing the temperature desired. The test for water or other impurities is to draw a sample of the ammonia from the liquid receiver into a test tube or beaker and allow it to boil as long as such action will continue at room temperature. The residue shows the amount of impurity present, which should never be more than a trace. The third takes into account air and disintegrated ammonia, which in time will accumulate in the condenser and increase the condenser pressure according to the law of partial pressures or Dalton's law. The test for this is to purge the condenser, a detail which should have attention at stated times. All these factors are extremely important where economical results are desired.

Seattle, Wash. H. J. MACINTIRE.

Results with a CO_2 Recorder

The city pumping plant of Phœnix, Ariz., consists of one Nordberg cross-compound Corliss unit and one Prescott unit with the same type of engine, operated at 180 lb. steam pressure, no superheat but the cylinders are steam-jacketed. Steam is generated by two B & W boilers of 130 rated horsepower each, fired with fuel oil through Peabody burners and furnaces. When we put in CO_2 instruments, I expected some saving, but was skeptical of much improvement on the pumpage we were getting per gallon of fuel consumed, as we considered that it was pretty good already.

The first charts showed, however, that we were getting only about 10 per cent. CO_2 in the daytime, and a little



TYPICAL CO_2 CHART FOR 24 HOURS

less at night, when the load was lighter; but we are now averaging 13 per cent. with the day load and 11 per cent. at night as a result of a study of conditions by means of the recorder, the load conditions remaining about the same. During the summer months, when the boilers are worked nearer their full capacity, we get as high as 14½ per cent. part of the time.

During 1915, 7355 gal. of water was pumped per gallon of fuel consumed, against a head of 130 ft. During 1916,

with a CO_2 recorder, the average jumped to 7888 gal. against the same head. In other words, we pumped 26 million gallons more water than in 1915 and consumed 8300 gal. less fuel, which is equivalent to a saving of 11,790 gal. fuel at 3½c. per gal., or $412, for a corresponding amount of water pumped. The instrument cost $150, so the investment was a paying one.

Our best record for one month is 8676 gal. of water against 130 ft. head per gallon of fuel oil, or reduced to foot-pounds, equals about 9,400,000 ft.-lb. per gal., or 1,150,000 ft.-lb. per lb. of fuel, not including deduction for slippage.

Steam plants in Arizona are far between, and I do not have the pleasure of visiting many, but I would suggest that the engineers read the excellent article by Mr. Azbe in the issue of Jan. 23, page 117. Any engineer who does not believe in such apparatus can get about 100 per cent. on his investment in a good book on combustion, firing, draft, heat losses, etc.

As I live in the West, I have not had much coal-firing experience, but presume that oil has some advantages which enable the fireman to make a more constant CO_2 record. Unless the oil fuel is extremely heavy, one can keep a clean furnace and produce but little smoke. Coal firing requires a greater excess air, yet the greatest waste in oil firing is too much air.

We have the regular Peabody type of furnace with the "rear shot burner." The flame carries slowly toward the front door, and through the small side door it can be seen to curl back again, and at times seems almost to be standing still, thereby giving up a large part of its heat. As an experiment, if the damper is opened wide there will be quite a change observed; the flame will not come so near the front door, but will be thrown upward or lifted by the draft and will be broken up against the tubes a short distance from the burner. Without reducing the fuel supply, the furnace temperature will fall several hundred degrees and the steam pressure will drop.

To anyone who has not experimented, I would suggest closing the dampers as near shut as possible without making smoke. If the steam pressure increases, keep the damper so and try other stunts that may also improve conditions. I am convinced that a study of the theory is needed along with practice, and either one without the other will not get very far up the hill of efficiency.

Phœnix, Ariz. J. F. REYNOLDS.

Anchor Bolt Was Loose

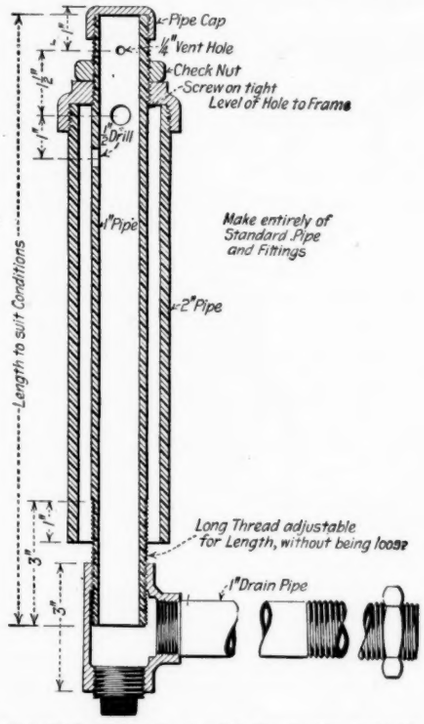
One of our generators developed a prolonged buzzing noise that did not depend on any load condition nor did a change of speed affect it any. It seemed to come and go, but its source could not be located. Every night, after the machine was shut down, I would look for the trouble. The stator and rotor were looked over first for anything loose, but nothing was found wrong. Next, I looked to see if any of the guard pieces that project over the stator windings were loose, but every one was tight.

One night while wiping up I happened to kick one of the bottom guard pieces and it sounded as if it was broken. On investigation, one of the ribs of the guard was found cracked. However, it did not seem that this could be the source of trouble, as I figured if it was the cause, the noise would be steady and not intermittent. In order to make sure, I taped the broken ends firmly together; nevertheless, when the machine was again put into service the noise was still there. The following night I decided to try the anchor bolts of the generator, using a rawhide hammer. After tapping three of these bolts, the fourth was found to be loose. After this was tightened, the noise disappeared, and it has not been heard since.

Middletown, N. Y. THOMAS M. GRAY.

Engine-Frame Oil Separator

In some engines using the splash system of oiling there is a false head placed in the end of the crosshead barrel or end of the frame, and the rod is packed with two or three rings of packing, forming a reservoir for the water that may work out from the cylinder through the packing and prevent it from getting into the oiling system. Some oil works into this space which, if wasted with the water, would mean considerable loss in a year. In order to save this oil, there is a hole through the false head at a certain level and the oil is supposed to drain back into the frame, and the water must be drained off at the bottom at intervals to prevent it from flooding over into the oiling system.



BOTTOM INLET TO OVERFLOW DRAIN

We have several engines equipped with a drain for the water, made as shown in the illustration, by means of which the oil is saved without allowing water to get into the oiling system. The separator is placed within the reservoir space with the drain pipe extending out at some convenient point, and the action is as follows: The water rises in the outer pipe until it reaches the level of the holes in the inner pipe, when it flows down the inner pipe and out to the sewer. The height of the overflow holes in the inner pipe is just below the level of the oil hole in the frame, so that the water cannot rise high enough to flow into the frame unless the drain pipe becomes stopped up. A siphon action is avoided by the vent hole at the top, and the oil is drained back into the engine frame through the regular overflow.

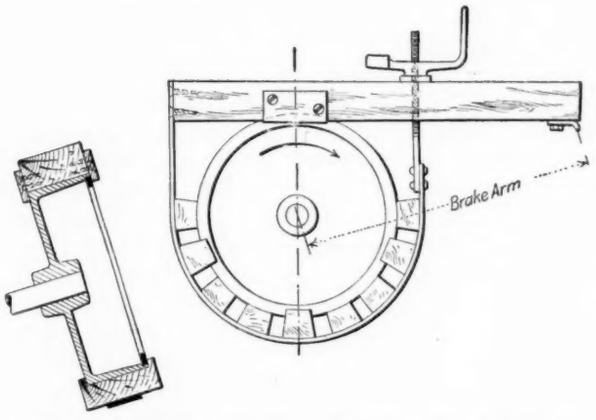
The length of the pipes must be determined as necessary for any given engine to bring the lower holes at the desired high-water level. There are other places where such an oil and water separator may be used, so that water may be drawn off from the bottom of the tank or other receptacle and the oil from the top at a level slightly above the water line. J. C. HAWKINS.

Hyattsville, Md.

Prony-Brake Discussion

The contribution in the issue of Mar. 6, page 322, by R. S. Bayard, "An Improvised Prony Brake," is interesting, but the brake is capable of considerable improvement. It would have been much cheaper to have cut notches in two or three of the brake blocks or to have fastened flanges to them, as shown in the illustration, than to have turned down the pulley to form flanges as indicated. It is desirable to bend the inlet water pipe in such a way that the stream will enter in the same direction as the wheel is revolving, to prevent splashing.

If it is necessary to remove the load rapidly, and it often is in testing internal-combustion engines at full load, the adjusting handle shown does not require so much time to loosen, as the nut may be turned rapidly with one hand and the pull rod or the opposite handle will not catch the wrist.



HOW THE BEAM LENGTH SHOULD BE OBTAINED

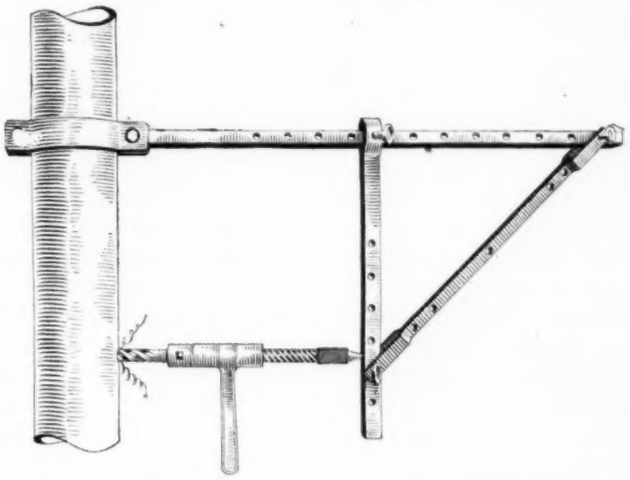
Emphasis is placed on the importance of getting the length of the arm, yet the illustration shows the length of arm measured on one side of a right-angle triangle instead of on the hypotenuse, introducing an error of considerable magnitude. The knife-edge shown on the end of the brake arm presupposes the use of a platform scale, which requires a vertical application of the load, therefore to get correct results the knife-edge should be on the same horizontal line as the center of the shaft and the length is to be taken from the center of shaft to the knife-edge, as shown in Fig. 2.

Indianapolis, Ind. C. E. SARGENT.

[Our correspondent is in error with regard to the length of the brake arm. It is the shortest distance between parallel lines, one drawn through the point at which the pressure is applied to the scale and *in the direction of such application,* and the other through the shaft center, and is correctly indicated in Fig. 3, page 322, where the pressure of the point on the end of the brake arm is exerted vertically downward.—Editor.]

Handy Ratchet Brace for Pipes

An "old man" that is handy for use with a ratchet drill, avoiding the usual trouble in getting it fixed solidly, consists of two 1¼-in. bars, a brace and a clamp, as shown. To use this outfit a suitable clamp must be made for the particular size of pipe or shape and size of column to be drilled. A number of small holes should be drilled and countersunk to receive the tapered "center" of the ratchet. The brace is most conveniently made of two bars shaped and riveted together as shown. The same outfit can be used on square columns, I-beams, etc., by having the clamp made of a suitable shape. JAMES E. NOBLE.



RATCHET BRACE, OR "OLD MAN," ATTACHED TO PIPE

Portsmouth, Ont., Canada.

Reducing Valve Not Faulty

In a small packing house that had been in operation only a few months, a reducing valve for the rendering tanks and other steam devices began to act in an erratic manner. It would allow the pressure to run up on a light load and fail to maintain enough at other times even when the spring was screwed down to the limit. Complaint was made to the manufacturer, who sent a man out to look the valve over.

When taken apart, it was found so badly scored that regrinding was impossible, so a new valve was sent out, but in a few weeks this was as bad as the old one. About that time I happened to drop in for a social call, and the engineer asked my opinion about it. As the valve was not in service at the time, it was disconnected and opened up for inspection. It was so badly scored that it looked more like a rough casting than a valve, and it seemed that the material must be defective; but the first one had cut the same way, and the valve was made by a manufacturer with a reputation for first-class goods. Difficulty in keeping up the pressure on full load suggested an investigation as to how much the full load amounted to. (In justice to the engineer it should be said that he was not responsible for the layout.) The valve and the line leading to it was 1½ in., and from this were taken four 1¼-in. lines to four rendering tanks, 6 ft. in diameter by 16 ft. high, and these were at times all in operation. When first started, they acted very much like first-rate condensers and the steam velocity must have been something

terrific. In addition to the tanks, there were more vats and all the radiators in the building.

To remedy the trouble, I recommended the installation of a 2½-in. valve for the tanks and vats alone, leaving the 1½-in. valve to take care of the radiators and a small water tank; and when this was done, no further trouble was experienced. E. W. MILLER.

Minneapolis, Minn.

Why He Wasn't

Your readers are indebted to you in these stressful days for the delightful humor of your editorial comment in the Apr. 17 issue, on the recent power-plant meeting of the Boston Sections of the A. S. M. E. and the A. I. E. E. But is there not a chance that in our enjoyment of your fun the deeper significance of what actually happened may be lost? In one letter from the committee I was informed: "We have already experienced antagonism from the Edison Co., who may not have any representative present or take part at all, for they think we are treading on their property and interfering with their particular business"; and again a month later this admission was made: "It is true the Edison people forced a readjustment of our plans." Depressing as the statement may be, there can be no doubt that the letter from Charles L. Edgar, member A. S. M. E. and president of the Boston Edison Co., in which he protested against the discussion of municipal plants, was the dominant fact of the meeting. Before this plea of the private-utility interests, the matured plans of the committee, public policy, professional ethics, the promotion of the science of engineering and even common courtesy were as so many reeds shaken by the wind.

Your editorial might leave the reader in doubt as to the reason for my failure to appear after it had been announced that I would be one of the speakers. I am unwilling that there should be any such uncertainty. We have entirely too much pussy-footing and too little plain talk as to the methods by which the private-utility interests, martialed and led by the electric crowd, have just about corralled the engineering profession. In one official communication from the committee, I was not only invited to speak, but asked "to take a leading part in the meeting" and was further told that the committee "will of course do the right thing so far as expenses are concerned." Some days later and after I had expressed a willingness to do my bit, I was told that the committee had not decided definitely as to the point in the program where I was to be scheduled, but I was told in this same letter that I was being reserved as "one of our chief attractions." Without any further advice as to a change in plan, the program was printed without my name. In view of the fact that I had originally written to the committee quite at length, asking whether they were going to have a real meeting and not one primarily designed to pull wool over the eyes of the public and had been given every assurance on this score, it is quite clear that there was a distinct change in plan. Mr. Ballard first declined the invitation to speak on account of press of other engagements. He reconsidered only after being urged to do so. He was later notified by wire that the program was full and this just about the time other speakers were being requested by telephone to present papers.

The truth of the matter is that the Boston public is waking up to the fact that electrical service can be sold at a profit at much less than it has been accustomed to pay for it. There has been some talk of a municipal plant, and the Massachusetts Gas and Electric Commission is now holding hearings in an action to reduce the rates charged for public street lighting. The central-station interests knew that Mr. Ballard and I were familiar with this situation and would discuss it frankly and from the public point of view. This is the reason for this latest display of rough work. Engineers should understand that this is only one local manifestation of an influence which is always gnawing at the integrity of our profession. As I have on former occasions remarked, the electrical industry stands like a "curtain of fire," keeping the great body of professional engineers from carrying out the work which the peoples of the world are calling us to perform.

What is the answer? Surely not in the bowling out of an individual here and there or the upsetting of one or a dozen cliques. The only remedy will be found in the revamping of our engineering organizations on democratic lines so that we may have genuine representative government. With our present type of organization almost anybody with a selfish aim and plenty of commercial power can throttle us collectively even if they cannot do so individually. It is the absence of real representative government that makes it possible for purely commercial organizations to have headquarters in the Engineering Societies' Building. It is because we are governed by officials not responsible except in the most indirect fashion to the members, that our Engineering Societies' Building is officially used for purposes indictable before the Federal courts as well as in upward of forty states in the Union. Let us reorganize our engineering societies so that we can have district representation at conventions and in the selection and election of our officials. Otherwise we can look forward to our further decadence—unless perhaps some new engineering organization with ideals and a democratic system of control takes the field and sweeps our older societies into oblivion.

Philadelphia, Penn. MORRIS LLEWELLYN COOKE.

Sees Difficulty in Aligning Engine

In the Apr. 3 issue appears one of the articles on "Steam Engine Troubles," page 451. The writer, in describing a method of lining up engines, establishes centers in the rear end of the cylinder and the crank end of the guide, with a strip of wood and pieces of tin with small holes in the centers. The line is stretched through them for a test.

I do not understand how the author of the article can have this line stretched through the small holes in the tin and be able to tell anything about where the end of the line will touch on the permanent stands. As long as the line is in the holes in the tin, he can move the ends of the line anywhere to his stands, and it would not necessarily tell him if the engine was in line.

Oakland, Calif. J. MCGAVIN.

The Weight of Bare Copper Wire is 0.003 lb. per cir.mil per 1000 ft. Example: A wire of 10,380 cir.mils will weigh 10,380 × 0.003 = 31.14 lb. per 1000 ft. (approximately).

Inquiries of General Interest

Resetting Slipped Eccentric—How would a slipped eccentric of a D side-valve engine be reset without uncovering the valve? W. N.

Place the engine on one center and turn the eccentric around on the shaft in the direction of rotation of the engine and alternately setting the eccentric and slightly opening the throttle valve, find the position of the eccentric for which steam is just admitted to the proper side of the piston by observing the escape of steam from the indicator cock or cylinder pet-cock on the same side of the piston.

Size of Chimney for 300 Boiler Horsepower—What height and diameter of round brick chimney should be provided for two horizontal return-tubular boilers each 72-in. diameter by 18 ft. long? C. E.

The chimney height should be selected with reference to the height of surrounding buildings and the probable influence of any hills in the neighborhood that would cause atmospheric currents to "spill" down into the chimney flue. Allowing that the two boilers would be operated to a combined capacity of 300 boiler horsepower and providing for maximum consumption of 5 lb. of coal per horsepower per hour and ordinary length of horizontal flues without abrupt turns, a round brick chimney flue 80 ft. high should have a least diameter of 48 in.; for 100 ft. high, a least diameter of 44 in.; and for 125 ft. high, a least diameter of 42 in.

Single-Valve Engine Valve Setting by Indicator—What is the best method of procedure in setting the valve of a single-valve engine by the indicator? R. D.

If there is any doubt of the correctness of the indicator reducing motion, it should be tested by turning over the engine to obtain different fractional parts of the stroke, laid off on the guide, and ascertain whether corresponding fractional lengths of indicator diagrams are obtainable. With a correct reducing motion, setting the valve by the indicator then will consist simply in obtaining diagrams from the two ends of the cylinder as nearly alike as possible, first by adjusting the length of the valve rod and afterward by shifting the position of the eccentric until the events are properly timed. The valve should be set for normal running conditions of speed and load, but diagrams should also be taken with the engine overloaded and underloaded, to determine whether the valve acts properly throughout the range of running conditions.

Fusible Plugs for Return-Tubular Boilers—How should return-tubular boilers be supplied with fusible plugs? P. T.

One or more fusible plugs should be set in the rear head of the boiler not less than 2 in. above the upper row of tubes, measuring from the upper surface of the tubes to the center of the plug, with the plug projecting through the tube sheet not less than 1 in. Fusible plugs should be filled with tin that has a melting point between 400 and 500 deg. F., and the least diameter of the fusible metal should be not less than $\frac{1}{2}$ in., excepting where the maximum allowable working pressure is over 175 lb. per sq.in., in which case the least diameter should not be under $\frac{3}{4}$ in. As the fusible plug and its casing are likely to become covered with a nonconducting covering of soot from the outside and with incrustation from the inside of the boiler, the plugs should be scraped clean whenever the boiler is cleaned and, for greater safety, a fusible plug should not be used for a longer period than one year.

Allowance for Expansion and Contraction of Steam Pipe—In erecting a straight-run steam pipe 80 ft. long for conveying steam at 150 lb. gage pressure and 100 deg. superheat, what allowance should be made for expansion and contraction? H. V.

The lineal expansion or contraction of iron and of steel is about 0.0000065 of its length per degree F. increase or decrease of temperature. The temperature of saturated steam at 150 lb. gage, or about 165 lb. per sq.in. absolute, is 366 deg. F., and superheated 100 deg. F. the temperature would be 466 deg. F. If the pipe is fitted into place when at a temperature of 50 deg. F., afterward, when its temperature is raised to the temperature of the steam, its expansion in length would amount to $(466 - 50) \times 80 \times 12 \times 0.0000065 = 2.6$, or about $2\frac{5}{8}$ in. Assuming zero deg. F. to be the lowest temperature of the material when the pipe is not in use, then contraction from the length when erected would amount to $50 \times 80 \times 12 \times 0.0000065 = 0.312$, or about $\frac{5}{16}$ in., and the total expansion or contraction to be provided for would be about 3 in.

Changing Size of Governor Pulleys—What would be the effect of changing the size of the governor pulleys on an engine of the Corliss type? W. F.

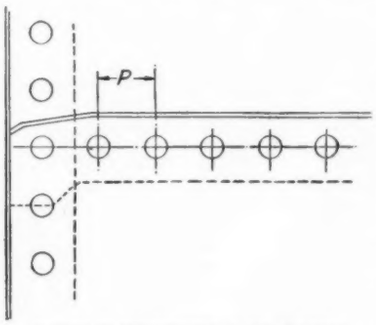
A small change in the speed of the governor changes the position of the governor balls from that required for full load to that required for no load, and to control the point of cutoff and thus regulate the supply of steam and the speed of the engine, the governor must be driven within the narrow limits of speed at which it is capable of operating. Any change made in the size of the governor driving pulley admits of a different speed of the engine for obtaining the normal speed required for operation of the governor, and the change results in placing the engine under the control of the governor at a changed speed of the engine. Hence the engine would be regulated at a higher speed by placing a smaller governor driving pulley on the engine shaft or a larger receiving pulley on the governor, because a higher speed of the engine would be attained in driving the governor at its normal speed, while a larger driving pulley or smaller receiving pulley would cause regulation of the engine at a slower speed.

Efficiency of Single-Riveted Lap Joint—What would be the efficiency of a single-riveted lap joint of $\frac{1}{4}$-in. plate of 55,000-lb. tensile strength and 95,000-lb. crushing strength, diameter of rivets after driving $\frac{11}{16}$ in., pitch $1\frac{3}{4}$ in., and shearing strengh of rivets 44,000 lb. per sq.in. of cross-section? R. G. M.

With thickness of plate $\frac{1}{4}$ in., pitch of rivets $1\frac{3}{4}$ in. and tensile strength of plate 55,000 lb. per sq.in. of cross-section, the strength of solid plate per unit of pitch (P in the sketch) would be

(A) $1.75 \times 0.25 \times 55{,}000 = 24{,}062$ lb.

The strength of the joint for a unit of the pitch would depend on the strength of the plate between the rivet holes, or the shearing strength of one rivet, or the crushing strength of the plate in front of one rivet. Having rivet holes $\frac{11}{16}$, or 0.6875, in. diameter, pitch of rivets 1.75 in. and tensile strength of plate 55,000 lb. per sq.in. of cross-section, the strength of plate between rivet holes would be



SINGLE-RIVETED LAP JOINT

(E) $(1.75 - 0.6875) \times 0.25 \times 55{,}000 = 14{,}609$ lb.

Having rivets $\frac{11}{16}$, or 0.6875, in. diameter, the cross-sectional area of one rivet would be $(0.6875 \times 0.6875) \times 0.7854 = 0.37122$ sq.in., and the shearing strength of one rivet would be

(C) $44{,}000 \times 0.37122 = 16{,}334$ lb.

The projected area of the plate material subjected to the crushing action of one rivet would be equal to the diameter of the rivet multiplied by the thickness of the plate, and with a crushing strength of 95,000 lb. per sq.in., the resistance of the plate to crushing in front of one rivet would be

(D) $0.6875 \times 0.25 \times 95{,}000$ lb. $= 16{,}328$ lb.

As the strength of the joint per unit of pitch would depend on (B), the strength of plate between rivet holes, the efficiency of the joint, compared with the strength of solid plate, would be

$$\frac{(B)}{(A)} = \frac{14{,}609}{24{,}062} \text{ or } 60.7 \text{ per cent.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Combustion in the Fuel Bed of Hand-Fired Furnaces

SYNOPSIS—A review of Bureau of Mines Technical Paper No. 137 dealing with combustion in the bed of fuels such as bituminous and anthracite coals and of coke. The CO_2 reaches a maximum at 4 in. above the grate in a 6-in. fuel bed with no ash on the grate. All the free oxygen in the air admitted under the grate is used up in the 6-in. fuel bed 4 in. above the grate. Complete combustion in good fuel bed impossible without air admission over the grate. Volatile distills in a reducing atmosphere.

Kreisinger, Ovitz and Augustine, in Bureau of Mines Technical Paper 137, describe some exceedingly interesting results of research into the combustion of coal and coke within the fuel bed of a hand-fired furnace. The results of the investigation furnish data for correct design of coal-burning grates and furnaces and their efficient operation. They also cast light on the important problem of clinker trouble as related to fusibility of ash. They further indicate the possibility of a high rate of gasification in coals with gas producers, as suggested in Bulletin No. 7 of the Bureau of Mines.

Perhaps the most interesting and valuable part of the report is the third part, which discusses the investigations described in the second part and includes about forty charts that show the composition of the gases and the temperature at different depths of the fuel bed of a hand-fired furnace, and various relations between the air supply and the rate of combustion. Many deductions are drawn from the charts, and the significance of these deductions in the operation of industrial furnaces is shown.

The authors, in their summary of results and conclusions, give the following:

The fuel bed in most types of furnaces acts primarily as a gas producer. With a 6-in. fuel bed the oxygen in the air rising through the grate is all used in combustion in the first 4 in. of the fuel bed from the grate up. At a distance of 4 in. from the grate the carbon-dioxide content of the gases has reached or passed a maximum of 10 to 16 per cent. and begins to drop. At the surface of the fuel bed the gases contain no oxygen, only 6 to 8 per cent. of carbon dioxide and 20 to 32 per cent. of combustible gases. The composition of the gases is practically independent of the rate of air supply. The larger the quantity of air forced through the fuel bed, the greater the rate at which the fuel burns or gasifies, but the ratio between weight of air supplied and weight of fuel burned remains constant at about 7 to 1.

In general the temperature in the fuel bed is highest 3 to 5 in. from the grate, which is also the point of maximum carbon-dioxide content. In the practical operation of boiler furnaces the significance of these results is as follows:

As most of the oxygen is consumed in the first 4 in. of the fuel bed, it is not necessary with the ordinary rates of combustion to run a fuel bed thicker than 4 to 6 in. to obtain a high carbon-dioxide and a low oxygen content in the fuel gases. The rate of combustion of gasification of coal depends on the amount of air that can be passed through the fuel bed. The thicker the fuel bed the higher is its resistance to the flow of air through it and the less air can be passed through with a given chimney draft. A thick fuel bed, therefore, reduces the rate of combustion and thus diminishes the capacity of the boiler.

A thick fuel bed is further undesirable because it increases the tendency of the coal to form troublesome clinkers. Perhaps the only apparently defensible excuse for carrying a thick fuel bed is the fact that the chances of burning holes in the fuel bed are reduced. A skillful fireman avoids holes in the fuel bed by firing frequently and placing coal on the thin or burned-out spots. A claim that fuel beds cannot be kept in good condition and carried thin is a confession of neglect and lack of skill. A fuel bed is understood to be only the layer of its active and freshly fired fuel and does not include the layer of dead ashes and clinker on the grate.

The ash fuses in the upper layers of the fuel bed, and as it sinks, it solidifies 2 in. to 4 in. from the grate. In most cases the fusion occurs in a reducing or partly reducing atmosphere; consequently in studying the fusibility of ash, the determination should be made in a partly reducing atmosphere.

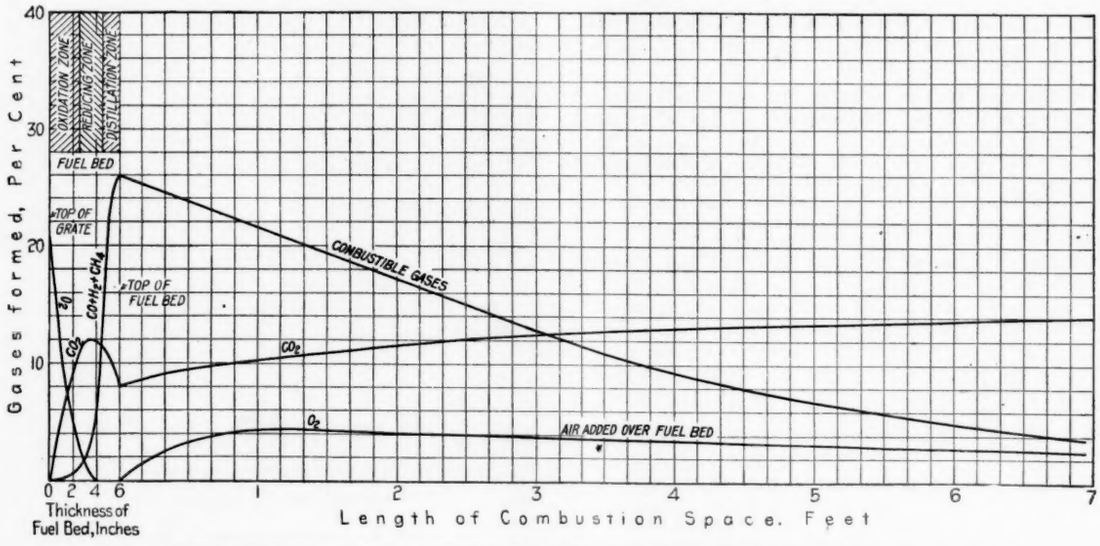


FIG. 1. INTERESTING CHART SHOWING COMBUSTION AS IT OCCURS IN A FUEL BED

At the surface of the fuel bed the gases contain 20 to 32 per cent. combustible gas and practically no free oxygen. To obtain complete combustion, additional air must be introduced over the fuel bed. This statement is true of all the fuels tested, including coke. As a general statement about one-half of the 15 lb. of air used to burn a pound of coal in a boiler furnace is supplied through the fuel bed; the other half must be supplied over the fuel bed.

A chart is contained in the paper, which shows the composition of gases in the fuel bed and in the combustion space beyond the fuel bed. The chart well brings out the effect of adding air above the fuel bed in order to complete combustion of the gases driven from the fuel bed.

In these tests samples of gases were taken from the fuel bed at intervals of 1½ in. from the grate, and temperatures were measured at the points where the samples were taken. The air supplied through the grate was measured with an orifice box. Two thicknesses of fuel bed were used, a 6-in. and a 12-in., and three kinds of fuel were tested—Pittsburgh coal, anthracite coal and coke. The rates of combustion varied from 20 to 185 lb. per sq.ft. of grate per hour.

The furnace in which the tests were made was a steel cylinder 22½ in. diameter and 30 in. high, lined with 4½ in. of firebrick. The space inside the lining was 13½ in. diameter, giving approximately one square foot of grate area. In the walls of the furnace were several §-in. holes for the insertion

of the gas samplers. The holes were in planes, spaced 1½ in. apart in a vertical direction and distributed radially around the furnace. The air spaces were about ½ in. wide and constituted approximately 60 per cent of the total grate area. The fuel was charged through the opening at the top of the furnace. Air was supplied to an orifice box under a pressure of 8 to 20 in. of water by a cupola blower belted to an electric motor. A flow of air through the orifice was controlled with a gate placed in the ducts between the fan and the orifice box.

A very important item of the tests which the engineer should notice is that all three fuels were sized by passing them over 1-in. square-mesh screen and through 1½-in. screen of the same type.

The thought that immediately jumps into the engineer's mind is that in actual operation there is no such sizing of coal; that the coal burned consists of anything from powder on up to large lumps; and he further appreciates that the character of the fuel bed not only has much to do with the rate of combustion and the flow of excess air through holes that may be in the fire, but clinker is influenced by the character of the coal, as well as by the size of the particles that go to make up the fuel bed. In brief, the sizing of coal, while it expedites the conducting of such a test as reported by the authors of the bulletin, brings about a condition that is seldom, if ever, found in a boiler furnace operating under commercial conditions.

OXYGEN ALL USED IN FUEL BED

The duration of tests varied from one to three hours, depending upon the rate of combustion. With low rates the tests were longer, and with high rates, shorter. All gas samples were collected through water-cooled sampling tubes, the gas being collected over mercury in glass receptacles.

The technical paper contains a table giving the results of the tests in a thorough and detailed way. This table gives the thickness of the fuel beds, the duration of the tests, the fuel fired per hour, the combustible burned per hour, the air forced through the fuel beds per hour, the weight of air per pound of fuel, the weight of air per pound of combustible, the distance of the sampling tube from the grate, and the gas constituents as taken at various depths of the fuel bed, as well as other information. The table takes up several pages, and space does not permit of its use here. Six sets of curves are given, which show the composition of the gases and the temperature at various depths in the fuel bed; the gases O_2 and CO_2 are represented by their chemical symbols. The total-combustible curve shows the sum of the percentages of total gases combustible ($CO + CH_4 + H_2$ + unsaturated hydrocarbon). The important fact shown by the chart is that with a 6-in. bed of Pittsburgh or anthracite coal the oxygen is all used up in combustion at a distance of 3 to 4½ in. above the grate in the fuel bed. The CO_2 content reaches a maximum of about 15 per cent. at a distance of 2 to 3 in. above the grate and then decreases until at the surface of the fuel bed it is 7 to 10 per cent. The percentage of combustible in the gases increases rapidly beyond 3 in. above the grate. At the surface of the fuel bed there is 20 to 32 per cent. of combustible in the gases and practically no oxygen. An interesting fact brought out is that the maximum temperature is at about the same height in the fuel bed as the maximum percentage of CO_2. In all tests there was at the surface of the fuel bed a large percentage of combustible gas and no oxygen to burn it, showing that the fuel bed of any hand-fired furnace acts primarily as a gas producer. In many tests the gas at the surface of the fuel bed would be considered a fairly good grade of producer gas.

CO_2 AN OXIDIZING AGENT

When the free oxygen is all used up, the CO_2 acts as an oxidizing agent, and by contact with the hot coal is reduced to CO. This reaction is expressed by the equation $CO_2 + C = 2CO$. The layer in the fuel bed where this process takes place is the reducing zone. It begins 2 to 3 in. above the grate and extends to the top of the fuel bed. The rate of combustion of CO_2 to CO depends upon the temperature of the fuel bed. The higher the temperature the faster the CO_2 is reduced to CO. The percentage of CO_2 that is reduced to CO at any given temperature depends up to a certain limit on the length of time that the CO_2 is in contact with the hot carbon. The longer the contact the larger is the percentage of CO_2 reduced to CO. The limit of reduction is the equilibrium between CO_2, CO and carbon at the temperature existing in the fuel bed. Beyond this limit the percentage of CO_2 does not change, no matter how long the time of contact may be.

Inasmuch as the temperature of the fuel bed in a hand-fired furnace is about 2400 deg. F., the reduction of CO_2 is very rapid, so that a large percentage is reduced to CO, although the time of contact is only a fraction of a second. With a given temperature the distillation is independent of the air supply, as when coal is heated the volatile matter distills off whether or not air is supplied. In a gas retort all the volatile matter in the charge is distilled off in complete absence in air. On the other hand, fixed carbon in a fuel bed cannot be burned to CO_2 or gasified to CO without air being supplied through the grate. This is an important fact to be considered in combustion of coal in hand-fired furnaces. When the supply of air through the fuel bed is shut off by clinker or ash on the grate, the combustion of the fixed carbon stops. If under such conditions the coal is fed into the furnace with undiminished rate, only the volatile matter is distilled off and burned in the combustion space with the air supplied over the fuel bed, while the fixed carbon accumulates on the fuel bed, rapidly increasing its thickness.

The tests further show the interesting fact that approximately one-fourth of the combustible rising from the fuel bed is in the form of tar, soot and other hydrocarbon compounds. In extreme cases, therefore, about 25 per cent. by weight of the combustible fired may go out of the chimney as black smoke. Extractions made on smoke collected from the chimney of a hand-fired horizontal tubular boiler showed only 3 to 6 per cent. of tar. This small percentage of tar in the chimney smoke as compared to that found at the surface of the fuel bed indicates the decomposition of the tar into gas and soot as it passes through the furnace.

The tests further showed that by increasing the rate of feeding air under the grate only, the rate of combustion is increased and not the weight of air used per pound of combustible. It is therefore impossible to regulate the excess of air in any hand-fired furnace by increasing or decreasing the flow of air through a level fuel bed; only the rate of combustion can be controlled thereby.

AIR MUST BE ADMITTED ABOVE THE GRATE

As the gases rising from the fuel bed contain a high percentage of combustible and no free oxygen, and as the air supply per pound of fuel cannot be increased by only increasing the rate of air supply to the fuel bed (under the grate), it is apparent that to obtain complete combustion some air must be admitted over the fuel bed. Thus the percentage of CO_2 in the gases of any hand-fired furnace can be controlled only by regulating the supply of air admitted over the fuel bed.

The authors say:

> It is well to state in this connection that forced-draft apparatus cannot supply enough air to a level fuel bed to insure complete combustion. Additional air must always be introduced over the fire in a manner such that it will mix with the combustible gases; otherwise a large percentage of them escapes unburned.

With a level fuel bed and an absolutely tight furnace perfect combustion would be impossible even when burning anthracite coal or coke. As the engineers will recognize, and as the authors also recognize, this condition seldom if ever prevails in practice, inasmuch as there is always, even in the tightest setting, considerable quantities of air entering the furnace above the grate. The fact that even as much as 40 per cent. excess air in the combustion of coal in a boiler furnace is not considered such bad, nor even uncommon, practice shows that air does find its way into the setting above the grate and through holes in the fire, even when quite thorough provisions are made to keep it out.

The authors further bring out that the ideal way to supply additional air over the fuel bed is to introduce it as close to the fuel bed and in as large a number of small streams as possible. The nearer the air is introduced to the surface of the fuel bed, the more combustion space is utilized for mixing with the combustible gases and for burning the mixture. A large number of small streams of air entering the furnace facilitates mixing the air with the combustible gases, particularly if it is forced in at high velocity. When the air is introduced in one large stream at low velocity, it tends to flow parallel to the streams of combustible gases without mixing with them, thus causing slow combustion. The rate of mixing determines the rapidity of combustion of the combustible gases. With a perfect mixture and the usual furnace temperature, the velocity of combustion is very great indeed, so that the combustion is almost in the nature of an explosion.

The writer of this review has had called to his attention furnaces of very small volume of combustion space, but in which were provided numerous small openings to obtain a thorough mixture of air with the gases of combustion right at the fuel bed, and even with coals high in volatile, practically complete combustion was had immediately above the fuel bed; whereas, if the same amount of coal of the same physical and chemical character were to be burned at a like combustion rate in a furnace in which no such provisions were made for causing a mixture of air with the combustible gases at the fuel bed, the furnace volume would need to be very much greater to obtain the same completeness of combustion.

In speaking of the effect of thickness of fuel bed on the pressure drop through the fuel bed, the authors state that with the same kind of fuel and the same rate of combustion an increase in thickness of fuel bed is accompanied with approximately a proportional increase in the pressure drop through the fuel bed. They well bring out that part of the deviation from this rule can be accounted for by the fact that the pressure drop is not altogether used to push the gases through the fuel bed, but also to impart to the gases the velocity with which they leave the fuel bed; that is, part of the static pressure under the fuel bed is converted into dynamic pressure at the fuel bed. The dynamic head should therefore always be considered in all measurements of pressure (draft) in boiler settings.

While the authors do not neglect the point, they seem to have lightly treated of the effect of the character of the fuel bed upon its resistance to the flow of air through it or about the pressure drop through it. For example, the coal that the experimenters used was coal that was sized, and although it broke up into smaller pieces during the process of combustion, the fact that it was sized would give an altogether different condition of pressure drop and air distribution through the fuel bed than occurs in a boiler operating under commercial conditions. This is particularly true of stoker-fired furnaces. In brief the rule as given by the authors certainly cannot be made to apply to a boiler in commercial operating conditions using the grades of coal that come into the fireroom and must be used. This is true, even neglecting consideration of the effect of clinker in increasing the pressure drop through the fuel bed and the effect on the uniformity of combustion over the whole surface of the grate.

ASH MELTS IN UPPER PART OF FUEL BED

Relative to ash fusion in the fuel bed, the authors have brought out the interesting fact that when clinker was formed the fusion of the ash occurred from 3 to 4 in. above the grate with 6-in. fuel beds, and even as high as 10 in. with 12-in. fuel beds. In the experimental furnace, each time the grate was shaken the ash could be seen to pass the hole that was 3 in. above the grate, in a half-fused, viscous state, showing that the fusing or softening of the ash took place in the upper layers of the fuel bed. The indications are that any fusion that occurs does so largely in the reducing zone of the fuel bed. As the half-molten, sticky ash sinks toward the grate, it passes into the oxidizing zone and solidifies, although this zone of the fuel bed, where the clinker solidifies, usually has the highest temperature. This is quite interesting. It should be remembered that the reducing zone contains not only combustible (reducing) gases, but also a considerable percentage of CO_2, which is not a reducing gas. The zone is called "reducing" because in it the CO_2 is being reduced to CO; a distinction must be made between reducing zone and reducing atmosphere. The authors refer to the work of Fieldner, Hall and Feild,[1] who found that the fusion temperature of coal ash is much lower in a partly reducing than in a strongly oxidizing or strongly reducing atmosphere. A study of the gas-composition charts given in the paper by Kreisinger, Ovitz and Augustine shows that melting occurs in the layer where the gases contain about 10 per cent. of combustible gases, 10 to 12 per cent. of CO_2, and very little or no oxygen.

Samples of gases collected in the fuel beds of different kinds of underfeed stokers particularly, show that the composition of the gases follow the same peculiarities, as to percentage of constituents for any particular place in the fuel bed, as was obtained in analyses of gases made from the fuel bed in the experimental boiler. In other words, these analyses show that the stoker, as well as the hand-fired boiler, is virtually a gas producer.

The later pages of the bulletin deal with explosions in boiler furnaces, and the authors have here again contributed something indeed worth while, as information relative to the explosion of gases in boiler furnaces is sorely needed, or at least a more general understanding of such explosions is imperative.

The authors show that the gases arising from the fuel bed contain 20 to 32 per cent. of combustible gases, which of course under the right conditions may produce a very highly explosive mixture. An explosive mixture can be formed in a boiler furnace in either of the two following ways: With a tight setting and tight fire-doors completely shut, so that no air is entering above the fuel bed, the furnace and the setting are filled with a combustible gas. If then the fire-doors are suddenly opened, a large volume of air is admitted into the furnace and mixes rapidly with the combustible gas. Under such conditions combustion of the gases may be so rapid that it assumes the violence of an explosion.

With the fire-door wide open, the furnace and the setting fill with air; if, then, a shovelful of slacky coal is spread over the fuel bed and the fire-door is quickly closed, the large volume of combustible gas rising from the freshly fired coal forms an explosive mixture with the air in the setting. Few firemen have not experienced both kinds of explosions. The first frequently occurs during the night, when the load is light and when the fires are being heavily charged; while the second occurs in a mild form when the boilers are more or less heavily loaded.

Of all the bulletins which the Bureau of Mines has published on the subject of the combustion of coal, this is without doubt its most important contribution to the subject. While the bulletin brings out much of what we have in a practical way known for a long time, the presentation of the subject in the form that it is given in this paper should certainly be of great value not only to those who are engaged in firing, but to those engaged in stoker design and furnace design and to those interested in smoke abatement.

[1]Fieldner, A. C., and Hall, A. E., "The Fusibility of Coal Ash in Various Atmospheres," "Journal Industrial Engineering Chemistry," Vol. 7, 1915, page 399; Fieldner, A. C., and Feild, A. L., "The Fusibility of Coal Ash in Mixtures of Hydrogen and Water Vapor," "Journal Industrial Engineering Chemistry," Vol. 7, 1915, page 742.

Boston Edison Plant Capacity

L. L. Elden, electrical superintendent of the Boston Edison Co., testified before the Massachusetts Gas and Electric Light Commission on Apr. 11, in the street-lighting arbitration proceedings, that the claims of the City of Boston relative to excessive reserve capacity at the L Street generating station did not take sufficient account of the vicissitudes of operation. This evidence was in rebuttal to the testimony of R. J. S. Pigott, who appeared on behalf of the city several weeks ago, as referred to in "Power" of Jan. 9, page 62.

In introducing the testimony relative to reserve capacity, F. M. Ives, counsel for the Boston company, introduced a letter from Vice President J. W. Lieb of the New York Edison Co. to C. L. Edgar, president of the Boston company, giving a detailed account of tie-line connections between the New York company and the plants of the Interborough Rapid Transit Co. and its predecessor, the Metropolitan Street Ry., since 1899. These connections include 10,000 kw. in feeder capacity in one case and 18,000 kw. in another and add materially to the reserve of the Interborough. The Boston Edison Co. maintained that Mr. Pigott did not allow sufficiently for the existing tie-lines in criticizing the amount of reserve capacity maintained at Boston.

The importance of an adequate reserve has been demonstrated, Mr. Elden said in the case of the Philadelphia Electric Co. within six or eight weeks, in which time the company lost 50,000 kw. in generating capacity, including a 35,000-kw. turbo-generator, the largest machine in the plant, and two 7500-kw. units, making it necessary to cut out a portion of the street-lighting service on two evenings.

Not long since, in a short period, the Boston Edison Co. lost the present use of 27,000 kw. of equipment, owing to a cable short-circuit outside the station, which bent a turbine shaft so that only part load could be carried, and on account of the burnout of compensators on one of the 13,200-volt turbines at the L Street Station.

The witness held that in view of the fact that the Boston Edison peak load has now passed 80,000 kw. and that a 30,000-kw. unit is being added to L Street, a reserve of at least 30,000 kw. in one or in two units should always be maintained. Describing the eight turbo units now in service at L Street, Mr. Elden said that tests made with these cleaned and in first-class condition show that very little reserve overload capacity can be counted upon from any of these units, except a moderate overload for the five or ten minutes required to put an additional machine into service, as follows:

No. of Unit	Manufacturer's Rating	Maximum Output
1	12,000 kw. contin.	13,000 kw.
2	12,000 kw. contin.	13,000 kw.
3	7,500 kw. 2-hour rat'g	8,500 kw.
4	7,500 kw. 2-hour rat'g	8,000 kw.
5	12,000 kw. 2-hour rat'g	13,000 kw.
6	15,000 kw. contin.	16,000 kw.
7	15,000 kw. contin.	15,000 kw.
8	15,000 kw. contin.	16,000 kw.

The capacity of all these units is limited by their condensing equipment. On account of the condensers becoming dirty and the wear of the edges of the turbine blades, increasing the clearance and leakage, with corresponding drops in turbine efficiency, the foregoing capacities cannot be maintained constantly.

Iron or Rust Cement—Fifty parts iron filing, one part chloride of ammonium or sal ammoniac. When it is to be used, it should be mixed with as much water as will give it a pasty consistence. This is an excellent cement for stopping cracks in iron tanks and the like.

Fuel Oil for Stationary Power Plants*

By Frederick Ewing†

SYNOPSIS—Mexico, with 40,000,000 barrels oil produced in 1916, has the world's largest fields. Owing to lack of necessity of banking, etc., combined efficiency is higher under everyday conditions, and maintenance costs are lower than with coal. Steam-jet burners are best suited to stationary boilers. Results of recent comparative boiler tests in New England are given.

Oil is now produced in large quantities in the following countries, eleven of which are given in the order of their production for the year 1915: United States, Russia, Mexico, Dutch East Indies, Roumania, India, Galicia, Japan, Peru, Germany, Trinidad. The world's total output for 1915 was 426,695,347 bbl., of which the United States produced 306,484,728 bbl., or about 72 per cent.

It is interesting to note that although oil was not produced in Mexico until 1901, in 1916 its yield was 40,000,000 bbl. Mexico now contains the largest oil fields in the world.

Some of the oil companies now offer long-term contracts of from three to five years at a fixed price and have large storage capacity in all chief American ports.

Fuel oil has been treated by a topping process, or partial distillation, the light and highly inflammable products, together with the moisture that invariably occurs in crude oil, being taken off. Oil used for fuel should have a flash point not under 150 deg. F. For this reason it can be used as fuel with the same safety as coal when the storage and burning facilities are properly provided.

Table I gives a typical analysis of the heavy fuel oil which is chiefly being offered at present.

TABLE I. TYPICAL FUEL-OIL ANALYSIS

Ultimate Chemical Analysis	
Moisture	Trace
Carbon, per cent	78.60
Hydrogen, per cent	13.26
Oxygen and nitrogen, per cent (by difference)	4.94
Sulphur, per cent	3.16
Mineral matter, per cent	0.04
	100.00
Physical Tests	
Specific gravity	0.9590
Specific gravity, deg. Baume	16
Flash point, deg. F	168
Fire point, deg. F.	256
B.t.u. per pound	18,500
Viscosity, Engler, at 212 deg. F., seconds	220

Plants which would show the greatest saving by adopting fuel oil come under the following classes: (1) Plants where the cost of coal handling is high. This may be due to the location of the plant in respect to tidewater or railroad delivery or to inadequate coal-handling machinery or where its installation would not be justified by the saving effected. (2) Plants that have a high boiler-room labor cost. (3) Plants that have limited boiler capacity or capacity limited by the stack cross-sectional area. (4) Plants situated in districts where smoke ordinances are severe. (5) Plants that have long stand-by periods as in power stations where many boilers are usually kept banked to care for sudden demands for increased power, or where the plant operates only eight or ten hours a day and the fires are banked for the rest of the time.

With oil fires may be regulated from a low to a most intense heat in a short time. This means a large saving in plants that are operated only twelve hours a day and carry their fires banked the rest of the time. On a 200-hp. return-tubular boiler about 3000 lb. of coal is used per week for banking fires at night and making new fires in the morning without doing any effective work. Similar tests on fuel oil show that it requires only 310 lb. of oil to do the same work. The saving during stand-by periods is well exemplified in a power station in New England. This plant for the last two months has carried two 500-hp. boilers banked, ready to be cut in on the line at a moment's notice, but as the demand for a sudden increase did not arise, all the coal used was wasted. The cost of banking these boilers was $300 a week. A saving in this plant of $2400 for these two months could have been made if oil had been the fuel used.

*Abstract of a paper read before joint meeting Boston Sections A. S. M. E. and A. I. E. E., Engineers' Club, Apr. 4, 1917.

†Mechanical engineer, Mexican Petroleum Corporation.

Considerable saving in labor, firemen, coal passers and ash handlers is possible, as only one fireman is required to operate from ten to fifteen boilers. For example, in a large plant in New England equipped with 15 Babcock and Wilcox boilers aggregating 5500 hp., which operates three eight-hour shifts per day, when burning coal 63 men were employed in the boiler room, but after the plant was converted to fuel oil this number was reduced to 7. Generally from 10 to 75 per cent. increased capacity can be obtained by using fuel oil. As the stack area required for burning oil is only 60 per cent. of that required for the same combustion rate for coal, 40 per cent. more power can be developed from the same stack.

Disregarding the small structural differences between oil burners, all may be brought under three classes, each of which has its own particular field; these are: Steam jet, which use steam as the atomizing agent; air jet, which use compressed air; mechanical, which use neither steam nor air, but break up the oil by heat and pressure and the mechanical construction of the burner. To obtain high efficiency with fuel oil, not as much depends on the type of burner selected as on the manner in which the oil-burning equipment is installed and operated. This work should be left to those who have had extended practical experience in the burning of oil under all types of boilers.

In nearly all fuel-oil installations under stationary boilers steam is the atomizing agent. It takes practically the same amount of steam to operate an air compressor for supplying compressed air for atomizing as it does to atomize the oil direct with steam. Mechanical burners require from 1½ to 3 per cent. of the total steam generated for operating the oil pump and heating the oil; steam atomizing burners require from 2 to 5 per cent. for the same purpose and for atomizing the oil.

STEAM ATOMIZATION FOR STATIONARY BOILERS

Although mechanical burners are more economical in the consumption of steam, this economy is offset by many disadvantages when used in stationary plants. A mechanical burner has not the range or flexibility of a steam burner and requires more attention and cleaning. Range and flexibility are of the utmost importance, as it is seldom that boiler plants are operated at steady load.

A mechanical burner must be run at practically full capacity, and the size of the flame can be changed only by inserting in the burner a tip with a larger or smaller opening, as the case may be. On the other hand, a steam atomizing burner can be operated from a low to a most intense flame by simply closing or opening the oil and steam-control valves. Any increased demand on the boiler can be taken care of instantly.

The chief requirements for burning fuel oil efficiently are as follows: The oil must be thoroughly atomized; after being atomized it must be brought into intimate contact with the requisite quantity of air for its combustion, and this quantity must at the same time be a minimum to lower the losses in the stack-gases; combustion must be complete before the gases come in contact with any firebrick or boiler-heating surface; there must be no localization of heat in the furnace; bridge-walls and target walls should never be used; the furnace should be designed to give depth and volume, which are determining factors affecting furnace efficiency and capacity; a fishtail flame burner is most satisfactory, as it spreads out the oil in a thin sheet and mixes well with the air for combustion; the oil should be heated to the correct temperature before it is atomized, this temperature varying with the particular oil used. If the oil is heated above its fire point, it will disintegrate and carbon will be formed, which will tend to clog the burner, and if the oil is not heated sufficiently, perfect atomization will not be obtained and imperfect combustion will follow.

One of the most important questions in the combustion of fuel oil is the regulation of the air supply. In a properly designed furnace the grate bars are removed and a firebrick floor with carefully planned air openings is laid on pieces of 2-in. pipe extending across the fire-box. The air supply is admitted through these openings in the furnace floor so that it will come in close contact with the atomized oil and complete combustion will take place before the gases come in contact with the heating surface of the boiler.

The required amount of air should be regulated by opening or closing the stack damper and not by opening or closing the ashpit doors, which should be left open at all times. Regulating the air supply is generally done by hand, but a more satisfactory and economical way is by the use of an automatic damper regulator operated by the gas pressure in the furnace.

The most efficient draft at which an oil-fired boiler should be operated is from 0.01 to 0.06 in., depending on the capacity at which the boiler is operated. A slight variation in the air supply will affect furnace conditions in an oil-burning boiler more than the same variations where coal is used, therefore particular attention should be paid to this point. Fuel-oil installations should be as far as possible in duplicate.

The speed of the pumps should be regulated by a diaphragm valve connected to the main steam line. This will increase or lessen the quantity of oil fed to the burners, as may be demanded.

The exhaust steam from the oil pump should be utilized to heat the oil before it reaches the burners. Strainers in duplicate should be installed on the discharge side of each pump. A circulating pipe system is essential, so that when starting the plant after it has been shut down and the oil allowed to become cold in the pipes, the burners can be bypassed and the oil circulated through the system and heated so that hot oil is supplied to the burners. Provision should be made for removing any condensation from the steam lines leading to the burners, and these lines should be thoroughly insulated.

In plants that shut down on Saturday until Monday morning, it is necessary to install a small auxiliary boiler, which can be fired with wood or coal so that steam can be provided for atomizing and operating the pumps when the plant is to be started.

It is impossible to give an exact comparison of efficiency between coal and oil for all plants, as no two are operated under similar conditions. Table II is taken from the 1914 Annual United States Geological Report on Petroleum, and gives the number of barrels of oil estimated to do the same work as a ton of various grades of coal under given conditions.

TABLE II. HEAT EQUIVALENTS OF SOME OILS AND COALS

One Pound of Combustible	Pounds of Water Evaporated at 212 Deg. F. per Pound of Combustible	Barrels of Petroleum Required To Do the Same Amount of Evaporation as One Ton of Coal
Petroleum 18 to 40 deg. Be	.....	.....
Pittsburgh lump and nut, Penn	10.0	4.0
Pittsburgh nut and slack, Penn	8.0	3.2
Anthracite, Penn	9.8	3.9
Indiana block	9.5	3.8
George's Creek lump, Md	10.0	4.0
New River, W. Va	9.7	3.8
Pocahontas lump, W. Va	10.5	4.2
Cardiff lump, Wales	10.0	4.0
Cape Breton, Canada	9.2	3.7
Nanaimo, British Columbia	7.3	2.9
Co-operative British Col	8.9	3.6
Greta, Wash	7.6	3.0
Carbon Hill, Wash	7.6	3.0

Under favorable conditions 1 lb. of oil will evaporate from 14 to 16 lb. of water from and at 212 deg.; 1 lb. of coal will evaporate from 7 to 10 lb. from and at 212 deg.; 1 lb. of natural gas will evaporate from 18 to 20 lb. from and at 212 degrees.

Table III gives the number of barrels of oil equal to several grades of Western coal and also to various kinds of wood.

TABLE III. OIL EQUIVALENTS OF COAL AND WOOD

2,000 lb. McAllister mine run (bitum.)	3.17 bbl. fuel oil
2,000 lb. McAllister slack (bitum.)	2.25 bbl. fuel oil
2,000 lb. Arkansas mine run (bitum.)	3.00 bbl. fuel oil
2,000 lb. Arkansas slack (bitum.)	2.50 bbl. fuel oil
2,000 lb. Eagle Pass lump (lignite)	2.75 bbl. fuel oil
2,000 lb. Rockdale lump (lignite)	2.38 bbl. fuel oil
2,000 lb. Lytle dump (lignite)	1.50 bbl. fuel oil
1 cord hickory wood	3.42 bbl. fuel oil
1 cord white oak wood	2.90 bbl. fuel oil
1 cord red oak wood	2.43 bbl. fuel oil
1 cord elm wood	1.78 bbl. fuel oil
1 cord pine wood	1.50 bbl. fuel oil

In the last three years several comparative boiler tests under regular service have been conducted at plants in New England to make a comparison between coal and fuel oil; the tests covered a period of one week each, starting with cold boilers Monday morning and continuing until Saturday, when the plants were shut down. Hammel oil-burning equipment was used throughout in each plant. [The complete items of these tests were given in the paper. Only the necessary comparative data are given here.—Editor.]

TABLE IV. COMPARATIVE RESULTS COAL AND OIL FUELS

	Manville Mill	Jenckes Spinning Co.	Bernon Mill	Riverside Mill
Evaporation per pound of coal from and at 212 deg. F	10.31	10.02	10.24	9.71
Evaporation per pound of oil from and at 212 deg. F	15.55	15.21	15.38	15.56
Combined efficiency with coal, per cent	68.0	66.6	68.1	67.2
Combined efficiency with oil, per cent	80.8	81.5	80.6	81.5

In "Power" for Mar. 13, R. L. Wales gives a quick method of determining the relative cost of coal and fuel oil, based on comparative efficiencies, and labor saving, in which he shows that 36 per cent. more per B.t.u. can be paid for oil than for coal.

Although a fair idea may be obtained of the comparative cost of coal and fuel oil by making certain reasonable assumptions, the only way to determine the exact saving is to operate the plant with each fuel for a period long enough to get the necessary data on which to make a final decision.

Steam-Driven Versus Motor-Driven Auxiliary Units

In the "Electrical Railway Journal" F. C. Chambers, mechanical and electrical engineer for the Des Moines City Ry., gives comparative costs of steam- and motor-driven auxiliaries supplied with energy from a small auxiliary high-pressure turbine-generator set, as worked out for determining the auxiliary equipment for the new power house of the Des Moines City Ry. The apparatus is figured for use with a 5000-kw. General Electric unit, which is to operate in conjunction with a 1000-kw. and a 2000-kw. unit in the present plant, adjacent to the new one.

The initial cost of the steam-driven equipment as figured is $7620, and of the motor-driven, $17,255, showing an excess of $9635 for the motor-driven over the steam-driven auxiliary equipment. The operating cost of the steam-driven auxiliaries was figured at $11,981 and that of the motor-driven, $9155, showing a saving in the annual operating cost in favor of the motor-driven equipment of $2826, which represents a saving of 29.33 per cent. per year on the excess investment in the motor-driven apparatus.

In the comparison of the two auxiliary systems, the blowers, house pumps, sunk pumps, etc., were planned to be motor-driven with either system, and in the operating cost of the steam-driven auxiliary the cost of current for driving these and the cost of the station capacity for supplying this energy were included.

No estimates of the comparative maintenance cost of the two systems were made, since no definite data relative to the cost of maintaining small turbines were available. However, it is undoubtedly true that the cost of maintaining one comparatively large turbine will be considerably less than that of maintaining a number of smaller units. The cost of maintenance of the motors would be practically nothing, as these will be of a slow-speed induction type.

The generating voltage of the auxiliary turbine set is stepped up through transformers, so that this source of energy may be connected to the main station bus and the surplus energy used to help carry the load of the plant.

The general plan of operation for the motor-driven auxiliaries is, to use the auxiliary turbine supplying energy to the motors as a means of furnishing just the amount of exhaust steam needed for feed-water heating and for heating the company's shops close at hand. In winter, instead of using live steam to make up the amount needed for heating, in addition to that supplied by the exhaust from the auxiliaries, as is the case with steam drive, the auxiliary turbine is loaded up electrically, sufficiently to supply the full demands of the shops and feed-water heating. In the summertime, when no exhaust steam is required for heating, the auxiliary turbine is loaded only to the point where it will supply enough exhaust steam for feed-water heating; the energy in excess of this required by the motors is supplied from the main bus through the transformers. By this means no live steam is supplied to the exhaust main. Whatever the requirement may be, it is supplied through the auxiliary turbine, which acts as a pressure-reducing valve.

The Southern California Edison Co., of Los Angeles, has applied to the State Water Commission for permission to appropriate 600 cu.ft. per sec. of the waters of the North Fork of the Kern River and of the Salmon Creek in Tulare County for the generation of electric power. The estimated cost of completing the project exclusive of transmission lines is given as $4,118,295. The name of the works is Kern River Plant No. 3. It is proposed to develop power by two hydraulic turbines, directly connected to alternating-current generators with a total capacity of 30,000 kw. The total fall to be utilized is 800 ft. between the forebay and the tailrace, and the amount of power is given as 54,545 hp. The application states that the proposed plant is to supplement the present plant of the company to meet the increasing demands for light and power and asks until July 1, 1922, to complete construction.

A Slow-Setting Rust Joint Cement—Two parts of sal ammoniac, one part of flower of sulphur and two hundred parts of iron filings.

Feed-Water Heater Kills Two

A not unprecedented but unusual accident occurred recently in the plant of the new American Express Co.'s building, 65 Broadway, New York City. A 900-hp. open feed-water heater of the exhaust-steam, cylindrical, cast-iron shell, internal-pan type blew out one of its heads, killing a steam fitter by striking him, and scalding to death his helper. A pipe coverer working near-by was so badly burned that at this writing he is not expected to live.

The heater was located above the floor, about 18 in. from the main steam header, which is welded; the other end of the heater faced a solid brick wall, a few feet away. The head of the heater let go, causing the shell to "sky-rocket" back from the wall, hitting the main steam header, which was uninjured. The plant was in operation and, as the heater knocked out the support of the 8-in. exhaust pipe, breaking it, exhaust steam filled the room. This is likely what led to the accident being reported as an explosion.

What probably caused the explosion was this: The heater filled with water at the house pressure, the overflow valve being closed for some unaccountable reason. The incoming steam making contact with the water produced water-hammer, subjecting the heater to a shock which ordinarily it would have withstood; but being under the house water pressure, it let go.

At the time of the accident the plant had not been turned over to the owners. The plant engineers are, therefore, not responsible for the accident. A new heater of the same design has been ordered and will be installed according to the plans and specifications under which the ruptured one was installed.

ENGINEERING AFFAIRS

The American Society for Testing Materials will hold its twentieth annual meeting in Atlantic City, N. J., June 26-29, with headquarters at the Hotel Traymore.

The National Gas Engine Association will hold its tenth annual meeting in Chicago, June 5-7, with headquarters at the Hotel Sherman. The following are among the papers to be presented: On Tuesday afternoon, "A Kerosene Carburetor," by Theodore C. Menges; "The Carburetion of Kerosene," by W. G. Clark. On Wednesday forenoon, "A Uniform Belt Speed for Gas Engines," and "Uniform Rating."

The New York Section A. S. M. E. held an enjoyable dinner and dance at the Machinery Club on Wednesday evening, Apr. 25. About 150 were in attendance. The speakers included President Hollis, who talked on citizenship; Commander E. P. Jessop, U. S. N., who made a strong plea for universal military service; and J. J. Swan, who outlined the plans for the Engineer Officers' Reserve Corps. E. J. Prindle presided. Those present were entertained by vocal selections rendered by A. D. Cornwall and Theo. Heinroth, and humorous stories by Mr. Oliver. Dancing followed.

The Eccentric Association of Firemen held its tenth annual ladies' night on Apr. 24, at its rooms 211 East 45th St., New York City. The attendance overflowed the main hall. An entertainment was furnished by Margaret Dougherty, Catharine Callery, Mae McMahon, Joe McKenna, Bob Jones, Harry Henry, Henry Frantzen and Jack Armour. National President Timothy Healy made a brief address presenting to newly-wed William M. Flanagan a silver service. Mr. Flanagan has been the secretary of the association for nineteen consecutive years. At the close of the entertainment refreshments were served. The committee comprised Brothers Smith, McDonough, McKnight and Duffy.

The American Institute of Steam Boiler Inspectors, Boston, No. 1, held the eighth annual dinner of the association Apr. 25, at the Copley Square Hotel, Boston, Mass. There was a good attendance of members and guests, considering that about 20 per cent. of the members have recently entered upon active service as commissioned officers of the engineering department of the U. S. Navy. A feature of leading interest was the presence of the dean of boiler inspectors, Andrew J. Savage, Retired Chief Inspector, U. S. Marine Inspection Service, whose reminiscences of early practice in the field of inspection were received with heartiest appreciation. C. H. Davis and J. H. McNeill, members of the American Institute of Steam Boiler Inspectors of New York City, delivered short addresses on workings of their association and the progress made toward the adoption of a New York State boiler code. At the bidding of President John H. Gleason, acting as toastmaster of the occasion, a number of other members and guests were heard from, including Prof. J. C. Riley, who gave an interesting description of special studies of gas and oil engine operation pursued by men from the U. S. Naval Reserve at the laboratories of the Massachusetts Institute of Technology.

Alumni Day of the Pratt Institute School of Science and Technology was celebrated on Saturday, Apr. 28. The sports began in the morning with a baseball game on the school grounds between the Mechanical Design and Electrical Departments, the latter winning by the score of 4 to 3. There was a parade, with a variety of appropriate floats and unique costumes. A skit by the members of classes A and E entitled "Billy Monday's Last Stand" was a big hit. In the evening a banquet was held in the Pratt Casino, where over 500 were seated. Patriotism was the keynote of the dinner. An illuminated picture of President Wilson was cheered to the echo. When the coffee was reached the toastmaster, M. F. Behar, introduced Jack Armour, of "Power," who told stories and recited. The speakers were Frederick B. Pratt, secretary of the institute; Leon P. Alford, of "Industrial Management"; Samuel S. Edmonds, director of schools; Arthur L. Williston, director of the Wentworth Institute, of Boston, Mass.; M. J. Shugrue, Class of '97; R. G. Winans, Class of '07. An engraved silver loving cup was presented to the Class of 97 for having the largest percentage of attendance to the annual dinners during the past twenty years. The newly elected officers are: William H. Bendernagel, president; William J. Moyer, Charles E. White, Marshal E. Stewart, vice presidents; A. W. Smith, secretary-treasurer pro tem.

The National Electric Light Association, having canceled, on account of the war, its convention scheduled for Atlantic City, May 29 to June 2, has substituted a special meeting to be held in the Engineering Societies Building May 9 and 10. The following tentative program has been announced: Wednesday, May 9, 10 a.m.: President's address, secretary's report, report of Public Policy Committee, addresses by some four to six prominent association members. Wednesday, May 9, 2:30 p.m.: General discussion on morning's addresses and formulation of definite recommendations to member companies for the conduct of their affairs in relation to the Government's plans for raising military forces and mobilizing the nation's industries. Thursday, May 10, 10 a.m.: Treasurer's report; appointment or election of special committees; election of nominating committee; Committee on Constitution and By-laws; Committee on Doherty and Billings Prizes; Committee on Memorials; Committee on Resolutions. Thursday, May 10, 2:30 p.m.: General and executive session; report of Committee on Constitution and Bylaws—Adoption; report of National Nominating Committee; report of Membership Committee; report of Committee on Safety Rules; report of Exhibition Committee, etc.; unfinished business. Thursday, May 10, 2:30 p.m.: Parallel executive and general meetings of all national sections for nominations, elections and reading of reports by title only.

BUSINESS NOTES

The McIntosh & Seymour Corporation's New York office is now located in the Singer Building, 149 Broadway.

The Anson-Byrne Co., sales agent for various mechanical equipment, has opened up new and larger offices in the same building, 10 South La Salle St., Chicago, Ill.

The Service Supply and Equipment Co., of Pittsburgh, Penn., will remove its sales office about May 1 from the Fulton Building to the Bessemer Building, where it will have larger and better quarters.

The Poole Engineering and Machine Co., of Baltimore, Md., recently acquired the exclusive manufacturing and selling rights of the turbo-gear formerly manufactured by the Turbo-Gear Co., Inc., of the same city.

Wauchope & Gale have established a consulting-engineering office at Twin Falls, Idaho. J. M. Wauchope was formerly connected with the Westinghouse force at Salt Lake City, and R. E. and R. L. Gale were formerly with the Judge Mining and Smelting Co., of the same city.

The Lunkenheimer Co., of Cincinnati, Ohio, is now occupying its newly erected and commodious building; which is about a block from the old location. It has all the facilities for prompt and efficient handling of materials, aided by a connecting railroad directly in the rear of the foundry.

The Southern Construction and Supply Co., supply specialist for ice-making and refrigerating plants, moved into its new building at 116-118 Central Ave., Atlanta, Ga., on Apr. 16. This company exclusively represents the York Manufacturing Co.'s products in the southeastern section of the country.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	May 5, 1917	One Year Ago	May 5, 1917	One Year Ago
Buckwheat	$3.40—4.40	$3.05—3.20	$6.50—6.75	$3.25—3.50
Rice	.....	2.50—2.65	5.50—5.75	2.70—2.95
Boiler	.....	.....	4.25—4.50	.....
Barley	2 65—3.65	2.20—2.35	4.15—4.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	May 5, 1917	One Year Ago	May 5, 1917	One Year Ago
Clearfields	$4.25—4.50	$1.40—1.90	$10.00—10.25	$4.25—5.00
Cambrias and Somersets	5.00—5.75	1.60—2.10	10.25—10 50	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $6.00—6.25, as compared with $2.75—2.85 a year ago; on cars Boston price is $11.25—11.50.
*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	May 5, 1917	One Year Ago	May 5, 1917	One Year Ago
Buckwheat	$3.70—3.80	$2.75	$6.00—6.25	$3.00—3.25
Rice	3.00—3.30	2.25	5 00—5.25	2.15—2.25
Barley	2.50—2.80	1.75	3.00—3.50	2.00—2.10

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.25—6.75	$6.25—6.75	$5 00—5.25
South Forks	6 50—6.75	.....	5 25—5.50
Nanty Glo	6.50—6.75	.....	5.25—5.50
Somerset	6.25—6 50	6.25—6.50	5.00—5.25
Quemahoning	6.50—6.75	6.50—6.75	5.25—5.50

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	May 5, 1917	One Year Ago	May 5, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.00	.90	3.00	1.80
Boiler	1.80	....	2.90	....
Barley	1.50	.55	1.75	1 30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	May 5, 1917	One Year Ago
Slack	$3.50—3.75	$1.05—1.15
Mine-run	3.75—4.00	1.20—1 30
¾-in.	3.75—4.00	1 30—1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$2.25—2.75	$2.25—2.75	$4.00—4 25	$2.00—2.25	$2.25—2.75
Lump	3.00—3.25	3.00—3 25	4.00—4.50	2.50—2.75	2.75—3 00
Egg	3.00—3.25	3.00—3.25	4.00—4 50	2.50—2.75	2.75—3.00
Nut	3.00—3 25	3.00—3 25	.....	2.50—2.75	2.75—3.00
No. 1 nut	3.00—3.25	3.00—3.25	.....	2.50—2.75	2.75—3.00
No. 2 nut	3 00—3.25	3 00—3.25	.....	.....	.....
No. 3 nut	2.75—3.00	2.75—3.00	.....	.....	.....
No. 1 washed	3.00—3.25	.....	.....	.....	.....
No. 2 washed	3 00—3.25	.....	.....	.....	.....
Mine-run	2 50—2.75	2 25—2.75	4.00—4.25	1.75—2.50	2.25—2.75
Screenings	2.50—3.00	2 25—2.75	.....	175—2.50	2.25—2.75

Hocking lump, $3.50—4.00; splint lump, $3.50—4.00.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	May 5, 1917	One Year Ago	May 5, 1917	One Year Ago	May 5, 1917	One Year Ago
6-in. lump	$3.25	$1.35—1.45	$2 00	$1.25—1.40	$2 00	$1.10
2-in. lump	3 25	1.20—1.35	2.00	1.15—1.25	1 85	.90
Steam egg	3.25	1 20—1.35	2.00	1.15—1.25	1.80	.90
Mine-run	2.75	1.05—1.20	2.00	1.05—1 15	1.85	.90
No. 1 nut	3.25	1.20—1.45	2.00	1 15—1.25	2.00	.90
2-in screen	2 50	.90—1.10	2.00	.85—1.00	1.85	.95
No. 5 washed	2.50	.90—1 10	2.00	.85—1.00	1.85	.90

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3 25—3.50	Carbon Hill	$2.75—3.00
Big Seam	2.75—3.00	Cahaba	3 25—3.50
Black Creek	3.25—3.50		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ariz., Mesa—City will hold an election on May 15 to vote on $125,000 bonds to construct an electric-light and power plant. W. A. MacDonald, City Clk.

Calif., Los Angeles—City election June 5 to vote on $12,000,000 power bonds. H. Hamlin, City Engr.

Conn., Hartford—The Clinton Electric Light and Power Co. will issue $100,000 bonds of which, $70,000 will be used for construction and extensions.

Fla., Pensacola—(Official)—Bureau of Supplies and Accounts, Navy Dept., Washington, soon to receive bids under Schedule 1029 for use at Navy Yard, 230-ft. single conductor, rubber insulated, double cable, 15,450-ft. single-conductor, paper insulated, lead-covered cable, 5005-ft. duplex, rubber-insulated, lead-covered cable.

Ill., Summit—City voted $6000 bonds to install additional street lighting equipment.

Iowa, Sioux City—The Sioux City Gas and Electric Co. plans to double the capacity of its plant. Plans include an addition of a 3000-kw. turbo-generator which will bring the total capacity of the station up to 8000-kw. Portion of old boiler room will be rebuilt and a new addition to the station erected to make room for new equipment. W. J. Bertke, Gen. Supt.

Maine, Farmington—The Franklin Power Co., recently incorporated with $300,000 capital stock, will develop water powers and build plant here to supply electricity and gas to Farmington and the surrounding towns. A. S. Gilman, Pres.

Md., Baltimore—The Consolidated Gas, Electric Light and Power Co., will construct a 2-story power plant at Race and Barney St. Estimated cost, $55,000. E. D. Edmonston, Lexington and Liberty St., Gen. Supt.

Mass., Adams—The Adams Woolen Mills will construct a substation in connection with the service to be given by the Connecticut Construction and Power Co.

Mich., Alpena—The City Council plans to install electric-lighting units in the business district.

Neb., Upland—City voted in favor of $6500 bonds to install an electric-light plant. The energy will be purchased from the Intermountain Railway, Light and Power Co., 412 Mining Exchange Bldg., Colorado Springs.

N. H., Claremont—The Claremont Power Co. will construct a new high-tension (44,000 volts) transmission line from Claremont to Charlestown to connect with the transmission system of the Connecticut River Power Co.

N. J., Jersey City—Bd. City Comrs. plan to install a new street-lighting system. C. A. Van Keuren, City Engr.

N. M., Gallup—The Mutual Coal, Light & Power Co. recently incorporated with $2,500,000 capital stock plans to build electric-light and power plants. G. A. Keeper, one of the incorporators, has been granted a 25-year franchise to supply electric service here.

N. Y., Bronxville—The Lawrence Park Heat, Light and Power Co., applied to the Public Service Commission for permission to construct and operate an electric-light and power plant.

N. Y., Rockwood—The Rockwood Manufacturing Co. is preparing plans for a hydro-electric power plant. Estimated cost, $300,000. D. W. Hyde, Gloversville, Pres.

N. D., Turtle Lake—The Central Power Co. has been granted a franchise to build a power plant at John Satterlund Mine and will furnish electricity in Turtle Lake, Washburn, Merger, McClusky, Denhoff and Goodrich. T. H. Fritts, Grand Island, Treas. and Mgr.

Ohio, Mechanicsburg—The Northwestern Ohio Light Co. has purchased a site here and will construct a substation. The energy will be transmitted from the company's plant at Urbana.

Ore., Baker—The Baker Mines Co. secured a franchise to build a power line from Halfway to Cornucopia for the operation of the company's mine.

Penn., Allentown—The Victor Leather Co. will construct a power plant at its new factory on Trout Creek. Franklin Haddock, Pres.

Penn., Carlisle—E. B. Beetem will construct a 1-story, 50 x 70-ft. power plant. A. J. Sauer & Co., Arch., is preparing plans.

Penn., Philadelphia—The Schuylkill Forge Co., 3d and Luzerne St., will construct a 35 x 41-ft. boiler plant.

Penn., Quakertown—Borough Council plans an election to vote on $45,000 bonds to reconstruct the electric-light plant.

R. I., Diamond Hill—City plans to install an electric-lighting system and may tap the transmission line of the Blackstone Valley Gas and Electric Co., 1 Clinton St., Woonsocket, which is being erected from Woonsocket to Plainville, Mass. and will pass through this town.

S. D., White Lake—City plans an election to vote on $10,000 bonds to install an electric-light plant.

Vt., Chittenden—The Pittsford Power Co., controlled by the General Gas and Electric Co., 50 Pine St., New York, will install a 200-kw. turbine at Chittenden and will construct a transmission line to the Castleton substation. B. T. Burt, Rutland, mgr.

Wash., Bremerton—(Official)—Bureau Supplies and Accounts, Navy Dept., Washington, will receive bids under Schedule 1003 for use at Puget Sound Navy Yard, lead pipe and seamless copper or bronzed pipe.

Wis., Chippewa Falls—The Wisconsin-Minnesota Light and Power Co. is having plans prepared for a high-tension transmission line from Wissota hydro-electric plant above here to La Crosse. A. E. Pierce, Eau Claire, 2d Vice Pres. and Gen. Mgr.